EBASCO

REM III PROGRAM

REMEDIAL PLANNING ACTIVITIES AT SELECTED UNCONTROLLED HAZARDOUS SUBSTANCE DISPOSAL SITES

DRAFT
VINELAND CHEMICAL COMPANY SITE
FEASIBILITY STUDY REPORT
UNION LAKE

JANUARY, 1989

EPA CONTRACT 68-01-7250

EBASCO SERVICES INCORPORATED

DRAFT
VINELAND CHEMICAL COMPANY SITE
FEASIBILITY STUDY REPORT
UNION LAKE

JANUARY, 1989

NOTICE

Mr. M. Shaheer Alvi, PE
Dr. Ferdinand Cataneo, PhD, PE

SUBJECT: DRAFT FEASIBILITY STUDY REPORT
VINELAND CHEMICAL COMPANY SITE
UNION LAKE
EPA WORK ASSIGNMENT NUMBER: 37-2LB8
EPA CONTRACT NUMBER: 68-01-7250

ACKNOWLEDGEMENT OF RECEIPT

Please acknowledge receipt of the Draft Feasibility Study Report by signing and returning the duplicate copy of this letter to the sender at the above address.

Signature ______________________ Date ______________________

EPA WORK ASSIGNMENT NUMBER: 37-2LB8
EPA CONTRACT NUMBER: 68-01-7250
EBASCO SERVICES INCORPORATED

DRAFT
VINELAND CHEMICAL COMPANY SITE
FEASIBILITY STUDY REPORT
UNION LAKE

JANUARY, 1989

Prepared by:

Raymond Nowak

Raymond Nowak
Site Manager
Ebasco Service Incorporated

Approved by:

Dev R. Sachdev

Dev R. Sachdev, PhD, PE
Regional Manager-Region II
Ebasco Services Incorporated

7103b

VINELAND CHEMICAL COMPANY
UNION LAKE

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

VINELAND CHEMICAL COMPANY
UNION LAKE

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The Union Lake Feasibility Study (FS) is one of three FS reports being prepared for the ViChem work assignment. The FSs include:

- The ViChem Plant Site proper
- The River Areas, consisting of the Blackwater Branch (the receiving stream from the ViChem plant) and the Maurice River from its confluence with the Blackwater Branch to Union Lake
- Union Lake, an 870-acre impoundment on the Maurice River

The ViChem Plant Site FS and the River Areas FS have been prepared and submitted to the USEPA.

Three Remedial Investigation (RI) reports have been prepared and submitted to the USEPA for the ViChem work assignment as follows:

- The ViChem Plant Site proper
- The River Areas, consisting of the Blackwater Branch, the Maurice River from its confluence with the Blackwater Branch to Union Lake, and the Maurice River below Union Lake to the Delaware Bay
- Union Lake

The purpose of the Union Lake FS was to develop, screen, and evaluate potential remedial alternatives to address sediment contamination found to cause increased health risks. This report was prepared in accordance with the USEPA's March 1988 Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.

The ViChem site is ranked among the top ten hazardous waste sites in New Jersey and is ranked number 41 on the National Priorities List. ViChem has manufactured organic arsenical herbicides and fungicides at this plant since 1949. The 54-acre facility is located in the northwest corner of the city of Vineland in Cumberland County, New Jersey. The plant is situated in a partly residential and partly industrial area.

The Blackwater Branch flows past the ViChem plant and receives groundwater discharge from it. From the plant, the Blackwater Branch flows approximately 1.5 miles before its confluence with the Maurice River. The Maurice River flows into Union Lake approximately 8.5 miles downstream from this confluence. The Maurice River flows into the Delaware Bay approximately 25 miles downstream from Union Lake.

Detailed information on the past use, storage, and disposal of all process materials at the plant is not available. It is known, however, that waste salts (listed hazardous waste #K031) containing arsenic were piled outdoors, and that precipitation contacting the piles flushed arsenic into the groundwater. Also, the plant previously discharged untreated process water into lagoons, and the water was allowed to percolate into the groundwater. The contaminated groundwater subsequently discharged into the Blackwater Branch and was distributed downstream in the Maurice River drainage system.

Previous investigations have shown elevated arsenic concentrations in surface waters and sediments as far as 26.5 river miles downstream from the plant in the Maurice River. It was suspected that a serious groundwater contamination problem existed at the plant.

In the Union Lake RI it was determined that arsenic was the main contaminant of concern. Pertinent findings from the RI are as follows:

- Arsenic was found to be the main contaminant of concern. The sediment and water in Union Lake both had elevated arsenic concentrations. The mean arsenic concentration in the sediment was 74 mg/kg. Upstream of the ViChem plant site, arsenic was undetected in the sediments. The mean total arsenic concentration in the lake water was 56 ug/l. This is slightly above the Federal Primary Drinking Water Standard for arsenic of 50 ug/l. Arsenic was undetected in the surface water upstream from the ViChem plant.

- Arsenic was detected in some fish samples at low concentrations (1 mg/kg). Low concentrations (less than 1 mg/kg) of PCB's were also detected in some fish samples. PCB's were not analyzed in the water and sediments of the lake. They were analyzed upstream from the lake, but were found only sporadically at low concentrations.

- The arsenic distribution in the sediments was very heterogeneous sediment. Samples taken in close proximity to one another varied greatly in arsenic concentration. While the data base within the lake was limited, in other areas in the basin arsenic correlated positively with increased organic content and increased fine size fraction content.

- Background studies performed by other investigators showed that arsenic bound very strongly to the organics in sediments. A maximum of 50% was leachable even under strongly acidic conditions. The estimated partition coefficient between arsenic on the organic sediments and water was a maximum of 1100.

Since Union Lake is part of a dynamic system, the fate and transport of arsenic within the watershed as a whole was pertinent to this FS. Findings from the other RI reports that relate to this FS are as follows:

- In the Plant Site RI, it was shown that groundwater discharge off the plant site was the main source of arsenic into the watershed. An estimated 6 metric tons of arsenic per year were being discharged into the Blackwater Branch from the plant site in 1987. The previous rate of release was probably much higher. The groundwater discharge flows into the Blackwater Branch; it does not flow beneath it.

- The Blackwater Branch and the upper Maurice River above Union Lake basically behave as conduits for arsenic transport. That is, they presently transport arsenic released from the site into Union Lake. Because of this, it was estimated that if the source of arsenic were eliminated (e.g., if a groundwater remediation program were initiated at the ViChem site to prohibit contaminated groundwater from entering the Blackwater Branch), then the river water arsenic concentration should drop relatively quickly.

- Union Lake has been a large receptor of the arsenic released from the site. Of the estimated 500 metric tons of arsenic released over time, an estimated 150 metric tons are now bound to Union Lake's sediments.

- It could not be determined what controlled the arsenic concentration in Union Lake's water. On one hand, the arsenic concentrations coming in, within, and going out of the lake were approximately the same. On the other hand, the lake's water and sediment were apparently at equilibrium, based on the mean arsenic concentration in the water and sediments and the partition coefficient. Therefore, the controlling mechanism for the lake's water arsenic content, the incoming water or desorption off the sediments, could not be determined. The significance of this was that if the source of arsenic into the basin were eliminated, it could not be definitively stated that the lake's arsenic concentration would also be reduced. Almost certainly it would be reduced, but how much and how quickly could not be determined.

The risk assessment presented in the RI considered a number of exposure pathways to the lake's water, sediment, and fish. Exposure scenarios were calculated considering recreational usage of the lake, since it is a popular recreational area. Risks were calculated on a "most plausible" and a "worst case" basis to provide a range of estimates. Risks were calculated for a range of conditions; lake full, lake drawn down for dam spillway reconstruction, and lake drawn down because of drought. Pertinent findings of the risk assessment were as follows:

- o Very little increased risk resulted from lake draw down. Risks during the period of draw down considered were in the range of 1×10^{-8}, or one predicted incident of cancer per one hundred million persons exposed.

- o Slightly increased risks were calculated for accidental water ingestion. The most plausible risks were approximately 6×10^{-6} (six incidents of cancer per million persons exposed), while the worst case risks were approximately 4×10^{-5} (four incidents of cancer per one hundred thousand persons exposed).

- o Increased risks from fish ingestion were calculated. The majority of the risks were from the low levels of PCB's found in the fish, not believed related to the ViChem site. The calculated arsenic risks from fish ingestion were probably overestimated since the form of arsenic in fish is believed to be relatively non-toxic.

- o Accidental sediment ingestion during recreation risks were 6×10^{-6} (six incidents of cancer per one hundred thousand persons exposed) by the most plausible pathway, and 7×10^{-4} (seven incidents of cancer per ten thousand persons exposed) by the worst case pathway. This pathway was considered valid only for sediments in very shallow water, less item two and one half feet deep.

- o To account for arsenic heterogeneity in the lake sediments and possible hot-spots, acceptable sediment arsenic concentrations were back calculated from the most plausible exposure pathways. A sediment arsenic concentration of 120 mg/kg back calculated to a risk of 1×10^{-5} (one incident of cancer per one hundred thousand people exposed). These sediments would be under very shallow water, less than two and one half feet deep.

A remedial action objective was established to address the contamination in the lake. Since the source of lake water contamination (the incoming water or desorption off the lake sediment) could not be determined, and because of the impracticality of treating the approximately 2.7 billion gallons of water in the lake discharging at a median rate of 350 cfs, remedial alternatives for the lake water were not considered. Also, since there was some question regarding the actual fish ingestion risks, remedial objectives for this problem were also not considered. Therefore, a remedial action objective was established for the contaminated sediments as follows:

- o Minimize public exposure, either through containment, removal, or institutional controls to areas with unacceptably high sediment arsenic concentrations.

This FS concentrated on remedial alternatives for contaminated sediments containing greater than 120 mg/kg arsenic under shallow water (less than two and one-half feet deep) in Union Lake. This represents approximately 130,000 cubic yards of sediment in place.

The target cleanup level corresponds to a sediment risk of $1x10^{-5}$ using the worst-case exposure pathway models, and $2x10^{-6}$ using the most plausible exposure pathway models. This risk level is consistent with that considered acceptable by the NJDEP at the Almend Road beach, a recreational area in the Maurice River upstream from the lake.

An interpretation of the site conditions by EPA Headquarters Site Policy and Guidance Branch personnel considered that the arsenic contaminated sediments in Union Lake were themselves the listed hazardous waste Number K 031. This is based on the belief that the lake's sediments were contaminated with arsenic from the listed hazardous waste K 031 produced at the ViChem plant. This interpretation requires that, if the sediments were excavated and treated as part of a remedial action, the treated sediments would have to be delisted before they could be disposed of as nonhazardous wastes.

Two bench-scale treatability tests were performed to meet the sediment cleanup objective: chemical fixation and chemical extraction. Based on the treatability studies, other information gathered in the RI, and other information from vendors, it was expected that the fixation could chemically stabilize or physically bind the arsenic to the sediments such that leachable arsenic concentrations would be less than 0.32 mg/l (as required by the VHS model, the substantive delisting tool). It is also expected that the fixed product would have an unconfined compressive strength of 1,500 pounds per square foot. By meeting these criteria, the fixed product would be expected to be delistable and could be disposed of in a nonhazardous waste landfill. The extraction test determined that arsenic could be removed from the sediments such that the extracted sediments had an arsenic concentration of 34 mg/kg. Based on results of EP Toxicity tests conducted on untreated sediments and other information gathered in the RI, it was expected that the extracted sediment would have leachable arsenic concentrations less than 0.32 mg/l. Thus it could be disposed of in a nonhazardous landfill. The supernatant could be treated to meet MCLs and could be discharged back to the lake. The sludge generated from the extraction process would be transported off-site to a RCRA treatment and disposal facility. Since both treatment technologies were successful in the tests, both were considered in the FS.

A number of general response actions and technologies were considered to achieve the remedial action objective. The general response actions include no action, containment, treatment, and removal.

Technologies to meet the general response actions were identified. Technologies for the no action response include monitoring, restricted use, and public awareness. Containment technologies include capping the sediments with sand, clay, and manmade liners. Removal and treatment technologies include dredging sediments under water, extracting or fixing the removed sediments, and in-situ treatment methods.

These technologies were screened to eliminate technologies that are (1) unproven, (2) would not meet the remedial action objective, and (3) would be difficult to implement due to the nature of the site and/or the nature of the contaminants.

The technologies that passed this screening were then combined to form overall remedial action alternatives in accordance with the NCP Section 300.68(f). The remedial alternatives considered for addressing the contamination were:

SOURCE CONTROL

- Alternative 1: No Action
- Alternative 2A: Dredging/Thickening/Fixation/Off-Site Nonhazardous Landfill
- Alternative 2B: Dredging/Thickening/Fixation/On-Site Nonhazardous Landfill
- Alternative 2C: Dredging/Thickening/Fixation/Deep Lake Deposition
- Alternative 3A: Dredging/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
- Alternative 3B: Dredging/Extraction/Sediment to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
- Alternative 3C: Dredging/Extraction/Deep Lake Deposition for the Sediments/Off-Site Hazardous Sludge Disposal
- Alternaive 4A: Dredging/Dewatering/Off-Site RCRA Disposal

- o Alternative 4B: Dredging/Dewatering/On-Site RCRA Disposal

- o Alternative 5: In-Situ Sand Cover

Dredging the sediments under water was common to all of the alternatives except for Alternative 1, No Action, and Alternative 5, In-Situ Sand Cover.

Alternatives 2A, 2B, 2C, 3A, 3B, and 3C differed from one another in the type of sediment treatment (fixation or extraction) and in the disposal options for the treated sediments (off-site in an existing nonhazardous landfill, on-site in a newly constructed nonhazardous landfill built for the treated sediments only or deep lake deposition of the treated sediments). Alternative 4A and 4B differed from the others in that the removed sediments would not be treated and would be disposed of in an existing off-site or in a newly constructed on-site RCRA Subtitle C landfill facility. Alternative 5 differed from the others in that the sediments would not be removed or treated. The in-situ sand layer would provide containment of the contaminated sediments.

An initial screening of these alternatives was performed based on three criteria: effectiveness, implementability, and cost. The alternatives were screened against these criteria, and were compared one against another to find the most promising alternatives to take into detailed evaluation.

Factors considered to determine an alternative's effectiveness were its ability to protect the public health and the environment, and its ability to reduce the mobility, toxicity, and the volume of the contamination. Factors considered to determine an alternative's implementability included its overall feasibility of implementation, its established or estimated reliability, and the availability of necessary equipment and services. Cost screening at this initial stage was performed on an order-of-magnitude basis, with only those alternatives that exceeded another's cost by an order of magnitude being eliminated on the basis of cost.

Alternative 1, No Action, was retained for evaluation because it serves as the base case against which the other alternatives were compared. Alternatives 2A, 2B, 3A, 3B, and 3C all met the remedial action objective, were considered implementable, and did not vary by an order of magnitude in costs. These were all retained for further detailed evaluation. Alternative 2C was not considered implementable. Fixation would immobilize the arsenic; no reduction in toxicity of the arsenic would be realized. If the fixated material leached appreciable amounts of arsenic to the lake, there is no feasible method to monitor or recover the deposited material. Therefore Alternative 2C was eliminated from further evaluation. Alternatives 4A and 4B were eliminated from further evaluation because they would not meet the forthcoming land disposal restrictions and would not provide for a permanent remedy.

The alternatives that passed the initial screening were then further evaluated in detail with respect to the nine criteria stipulated in CERCLA as amended, OSWER Directive No. 93SS.0-19 and the statutory factors described in OSWER Directive No. 93SS-21. The nine criteria are: short-term effectiveness; long term effectiveness; reduction of toxicity, mobility, and volume of contamination; implementability; cost; compliance with ARARs; overall protection of human health and the environment; state acceptance; and community acceptance. A summary of the detailed evaluation of the alternatives that passed the initial screening is discussed below.

SOURCE CONTROL

Alternative 1, No Action, provides the baseline against which the other responses can be compared. There would be no substantial remediation activities involved; therefore there would be no reduction in potential environmental contamination. Public access to the lake would be reduced by sign posting and educational programs. This would not meet the statutory requirements of reducing the toxicity, mobility, or volume of contaminants. This alternative is easy to implement, but would not attain ARARs.

Alternative 2A would entail dredging the contaminated sediments in the lake and treating them via fixation. The fixed product would be disposed in a nonhazardous off-site landfill. This alternative would reduce the cancer risk level to the target of 1×10^{-5} in the sediments identified as a public health risk. It would slightly reduce the toxicity, mobility, and volume of contaminants in the lake. It would reduce the mobility and volume of contaminants overall, but not their toxicity. Fixation binds the arsenic, it does not change its form. Long-term monitoring would be required to monitor the sediment redistribution patterns in the lake. If significant redistribution occurs causing a public health risk, additional remedial actions may be required. Possible environmental impacts include disturbing lake and adjacent areas during construction, and impacts from truck traffic.

Alternative 2B is the same as Alternative 2A except that the fixed sediments would be disposed of in a nonhazardous landfill built specifically for this purpose. The landfill would be constructed at the ViChem plant site. The same reductions in toxicity, mobility, and volume would be realized as with Alternative 2A, and the reduction of risk in the lake sediments would be achieved with the same potential dredging impacts. This alternative would also require long-term maintenance to insure that the landfill does not leach contaminants, as well as long-term monitoring of the remaining contaminated sediments.

Alternative 3A entails the same dredging activity as 2A and 2B. Instead of being fixated, however, the arsenic would be extracted from the sediments. The extracted sediments would be disposed of in an off-site nonhazardous landfill. The extractant would be treated with a fairly complicated system to remove arsenic prior to its discharge into the lake. The sludge containing the extracted arsenic would be transported off-site to a RCRA treatment and disposal facility by the vendor providing the extracting system. This alternative also reduces the toxicity, mobility, and volume of contaminants in the lake that were identified as a public health risk. The cancer risk level would be reduced to below 1×10^{-5}. Alternative 3A also reduces the toxicity and mobility of the contaminants overall, but not their volume. Long-term monitoring would be required to measure the effectiveness of this alternative. If sediment redistribution results in a public health risk, additional remedial actions may be required.

Alternative 3B is the same as 3A except that the extracted sediments are disposed of in an on-site nonhazardous landfill. The landfill would be located at the ViChem plant site. Administration approvals and land acquisition would be required. This alternative achieves the same reduction in toxicity, mobility, and volume of contaminants as 3A. Additional long-term maintenance and monitoring would be required to insure the landfill's integrity.

Table E-1 presents the present worth costs assuming a 5% discount rate for the alternatives at the 120 mg/kg action level. Because the O&M costs for all of the alternatives are either low or nonexistent, the costs are not sensitive to different discount rates.

TABLE E-1

SUMMARY OF COST ANALYSIS (1989 DOLLARS)
SOURCE CONTROL

ALTERNATIVE	CAPITAL COST			ANNUAL O&M	PRESENT WORTH; DISCOUNT RATE OF 5%
	DIRECT	INDIRECT	TOTAL		
1	35,000	9,450	44,450	47,200	839,580
2A	62,249,660	16,812,347	79,062,007	13,020	79,304,454
2B	45,520,840	12,290,627	57,811,467	92,730	59,112,407
3A	23,490,295	6,342,385	29,832,680	13,020	30,075,127
3B	15,589,346	4,209,124	19,798,470	59,060	20,652,296
3C	13,305,695	3,592,545	16,898,240	13,020	17,140,687
5	2,396,160	646,960	3,043,120	13,020	3,312,820

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) on May 9, 1986 authorized Ebasco Services Incorporated (Ebasco) to conduct a Remedial Investigation/Feasibility Study (RI/FS) of the Vineland Chemical Company (ViChem) site, Vineland, New Jersey. The RI/FS was performed in response to Work Assignment Number 37-2LB8 under Contract Number 68-01-7250. Preparation of this report was accomplished pursuant to the approved Work Plan for the ViChem site dated November 17, 1986 as amended on December 23, 1987.

Three RI and three FS reports will be prepared for the ViChem site to address the different environments studied. The study area is shown in Figures 1-1 and 1-2.

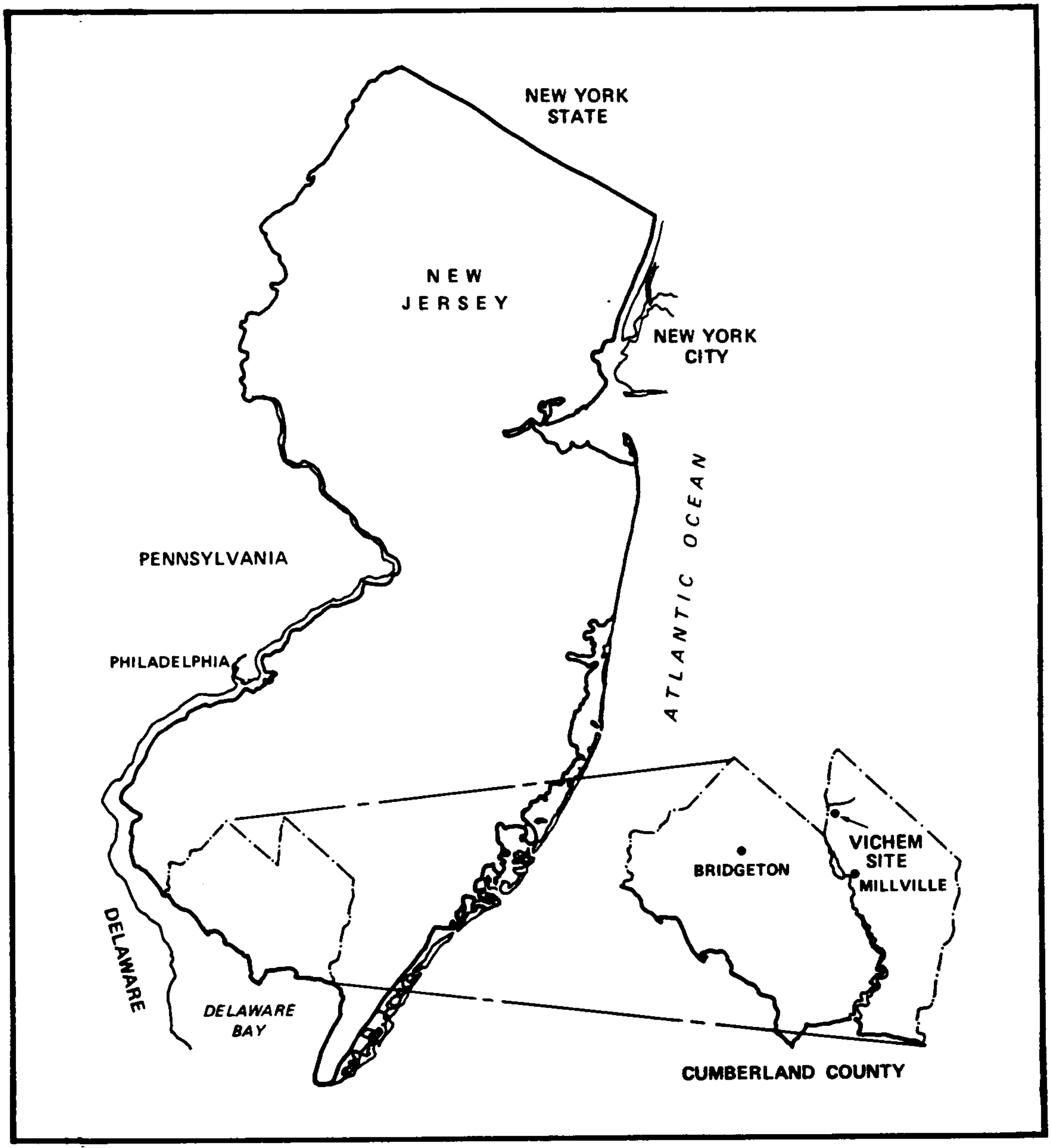
One RI report was prepared for each of the following areas, and was submitted in draft form to the EPA on the dates listed:

- o The ViChem plant site itself, submitted on July 19, 1988;
- o The River areas, consisting of the Blackwater Branch (the main receiving stream from the ViChem plant), the upper Maurice River between the Blackwater Branch and Union Lake, and the lower Maurice River south of Union Lake to the Delaware Bay, submitted on September 8, 1988; and
- o Union Lake, an 870 acre impoundment on the Maurice River, submitted on March 21, 1988 then reissued on June 24, 1988 incorporating a revised risk assessment.

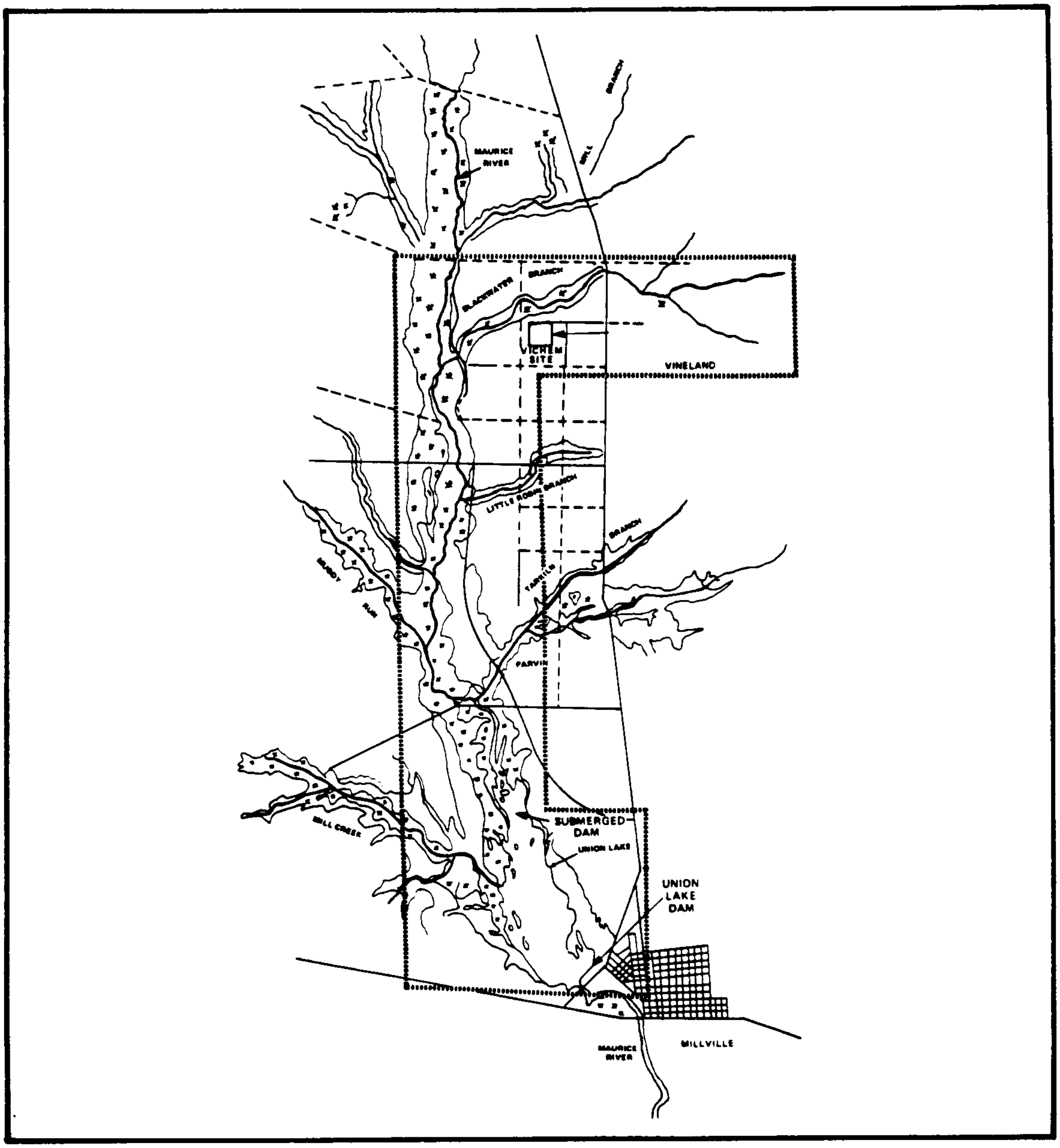
One FS report was prepared for each of the following areas, and was submitted to the EPA in draft form on the dates listed:

- o The ViChem plant site itself, submitted on September 20, 1988;
- o The River Areas, consisting of the Blackwater Branch and the Upper Maurice River, submitted on October 5, 1988; and
- o Union Lake.

This report presents the FS for Union Lake. No FS report is being prepared for the lower Maurice River south of Union Lake to the Delaware Bay. Sampling in this portion of the study area was confirmational only.



U.S. ENVIRONMENTAL PROTECTION AGENCY
VINELAND CHEMICAL COMPANY SITE
FIGURE 1—1 VINELAND CHEMICAL COMPANY REGIONAL LOCATION MAP
EBASCO SERVICES INCORPORATED



Source: RCRA Part B Permit Application prepared by Woodward Clyde Consultants for Vineland Chemical Company

SCALE 1:24,000

U.S. ENVIRONMENTAL PROTECTION AGENCY

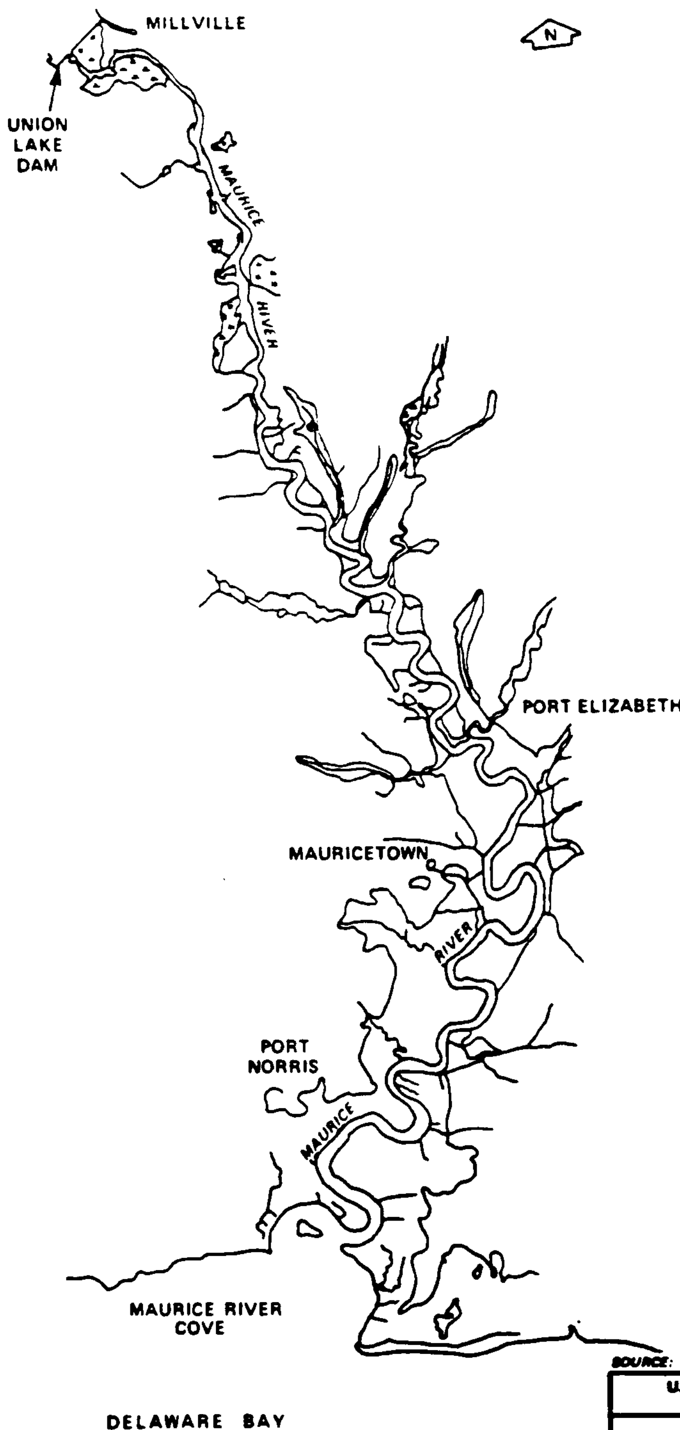
VINELAND CHEMICAL COMPANY SITE

FIGURE 1-2

VINELAND CHEMICAL COMPANY SITE STUDY AREA

SHEET 1 OF 2

EBASCO SERVICES INCORPORATED



SOURCE: NJDEP April 8, 1985 Memorandum.

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1-2

VINELAND CHEMICAL COMPANY
SITE STUDY AREA

SHEET 2 OF 2

EBASCO SERVICES INCORPORATED

1.1 PURPOSE AND ORGANIZATION OF REPORT

The objective of the Union Lake FS was to develop and screen feasible remedial alternatives, evaluating the most promising alternatives against a range of factors and comparing one against another. The FS provides a basis for the selection of a remedy. Specifically the Union Lake FS objectives were three-fold:

- o Identify and develop feasible remedial technologies for containment, removal and treatment of the arsenic contaminated sediments;
- o Screen and assemble the promising remedial alternatives for detailed analysis; and
- o Evaluate and compare the remedial alternatives to provide the necessary data for the selection of a remedy.

Subpart F of the National Contingency Plan (NCP) (40 CFR 300.61-300.71) sets forth the FS process by which remedial actions will be evaluated and selected. The factors to be considered in the process are cited under the requirements of Section 105.

This FS Report was prepared utilizing the data and information from the Draft Union Lake (RI) (Ebasco, 1988c). This report is comprised of four sections following EPA's draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988).

The Introduction, Section 1.0, provides background information regarding site location, site contamination, history, and regulatory actions. The nature and extent of the problem as identified through the RI and the risk assessment is also presented in this section.

Section 2.0 presents the feasible technologies identified for the general response actions, the technical criteria and site-specific requirements that were used in the technology selection process, and the results of the remedial technology screening. A summary of the objectives for remedial actions and the applicable environmental criteria and standards is also provided.

Section 3.0 presents the remedial alternatives, developed by combining the technologies identified in Section 2.0, in the three categories (no action, containment and treatment) required by the Superfund Amendments and Reauthorization Act (SARA). The process for screening remedial alternatives along with the environmental and public health impacts and estimated costs are also described.

Section 4.0 contains the detailed description of the cost and non-cost features of each remedial action alternative passing the screening in Section 3.0. This section presents the detailed evaluation process that was conducted and the results of the analysis of nine assessment criteria. Finally, this section summarizes the remedial alternatives and compares the remedial alernatives based on the results of the detailed evaluation. In addition, considerations for implementing the remedial alternatives are also discussed.

All of the references and previous studies cited in this document as well as the other documents used to conduct and prepare the FS are listed in the Reference Section.

This report contains three appendices:

- o Appendix A, Major Facilities and Construction Components, presents the construction components and associated quantities for the remedial alternatives in Section 4.0;

- o Appendix B, Capital and Operations and Maintenance (O&M) Cost Estimates, presents material and installation costs yielding direct and total construction costs for the remedial alternatives presented in Section 4.0, and presents the O&M costs for the alternatives required; and

- o Appendix C, Methods Used to Estimate Volume of Sediments for Removal, presents the methods used to estimate the volume of sediment to be removed at the chosen action level.

1.2 BACKGROUND INFORMATION

The ViChem site is ranked among the top ten hazardous waste sites in New Jersey. The site is ranked number 41 on the National Priorities List.

Arsenic contamination, attributable to ViChem, has been observed in groundwater and soil at the plant site. The arsenic has been distributed downstream in the Maurice River system. Previous investigations found elevated arsenic concentrations in surface waters as far as 26.5 river miles downstream from the plant.

This report presents the FS for Union Lake. A brief description of all of the areas studied during the work assignment is provided below.

- o ViChem Plant site - The ViChem Plant is a 54 acre active manufacturing facility which has produced organic arsenic herbicides and fungicides since 1949. Arsenic contamination has been observed in the soils and the groundwater at the ViChem Plant.

- Blackwater Branch - This is the stream which flows directly past the ViChem Plant. This relatively small stream drains an area of approximately 14 square miles above the plant, and receives the groundwater discharge from the plant. The stream flows into the Maurice River approximately 1.5 river miles downstream from the ViChem Plant.

- Maurice River - This is the stream into which the Blackwater Branch flows. From its confluence with the Blackwater Branch, the stream flows approximately seven river miles downstream into Union Lake. Coming out of the lake, the river flows approximately 25 river miles further downstream to the Delaware Bay.

- Union Lake - This is an impoundment on the Maurice River. The lake encompasses an area of approximately 870 acres at its normal pool elevation of 25 feet, and is approximately two miles long.

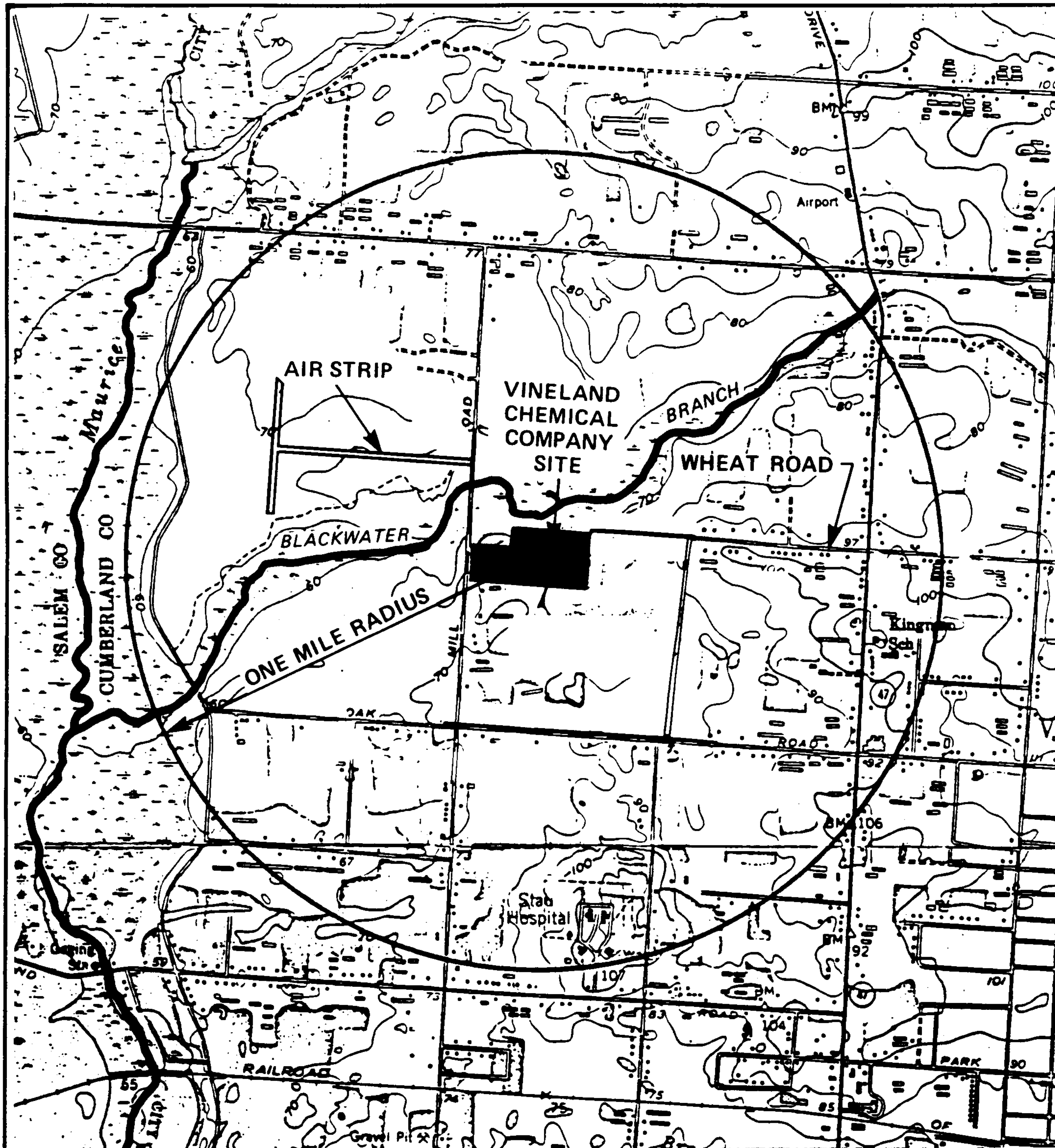
1.2.1 Site Description

The ViChem Plant is located in a residential/industrial area in the northwest corner of the city of Vineland. The plant location is shown in Figure 1-3.

ViChem has produced organic herbicides and fungicides at this location since approximately 1949. ViChem currently produces two major herbicidal chemicals, disodium methanearsonate and monosodium methanearsonate. Table 1-1 lists chemicals used, manufactured, or known to be stored at the ViChem Plant.

The ViChem Plant site is shown in Figure 1-4. The plant consists of several manufacturing and storage buildings, a laboratory, a worker change facility, a wastewater treatment plant and several lagoons. The manufacturing and parking areas shown in Figure 1-4 are paved. The lagoon area is unpaved and is devoid of vegetation. This area is dominated by loose sandy soils. The remainder of the site is covered by trees, grass, or shrubs.

A wastewater treatment system is in operation at the site. The system has a design capacity of approximately 25 gallons per minute (gpm), or 36,000 gallons per day (gpd) assuming 24 hours of continuous operation. The system was designed to treat between 2,000-5,000 gpd of process water, 20,000 gpd of groundwater, which was to be pumped from the shallow water table, and storm runoff water as necessary. In addition, provisions were made to collect up to 60,000 gpd of non-contact cooling water in the event that a mechanical breakdown occurred and mixed the non-contact cooling water with the contaminated process water.



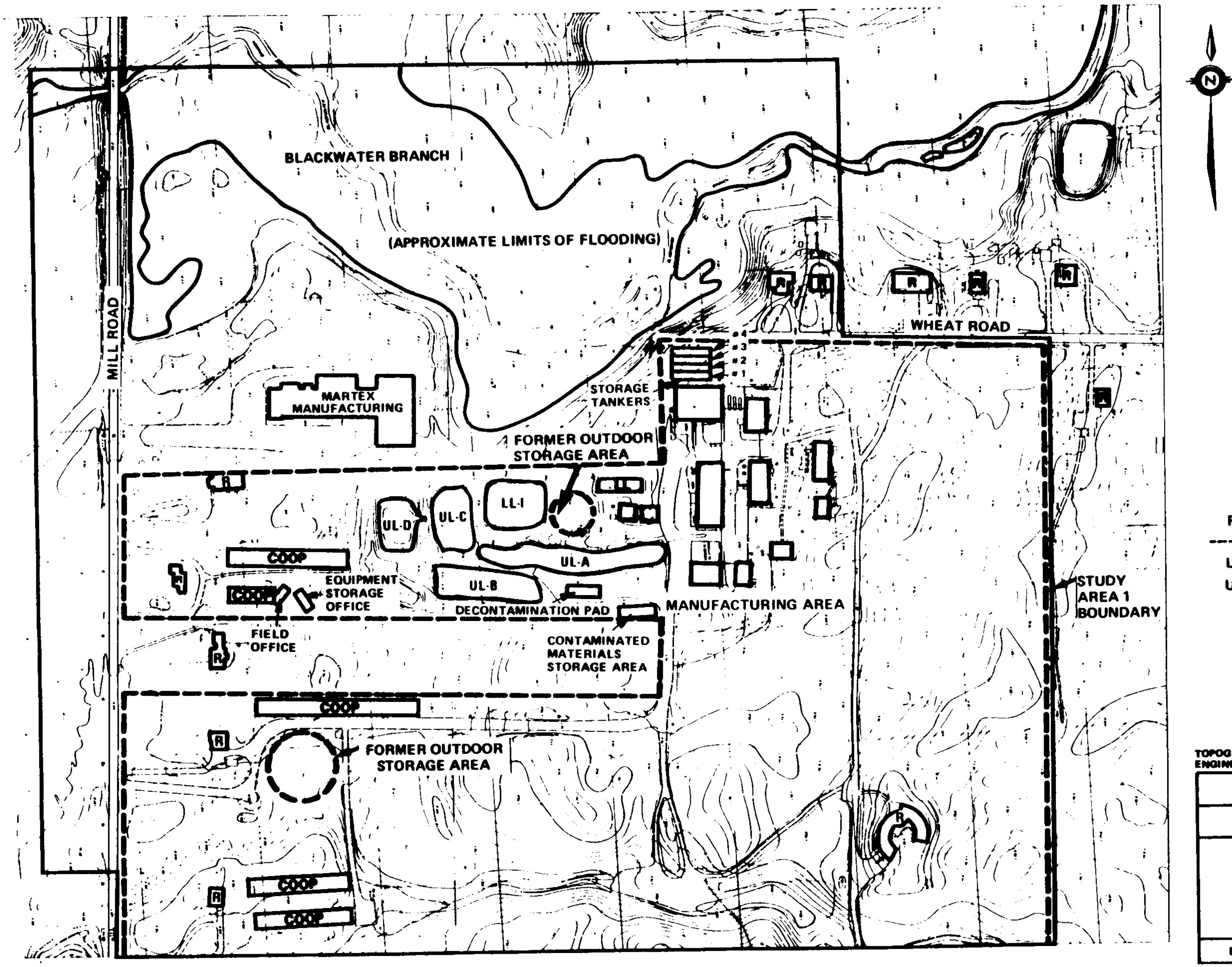
U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1–3

VINELAND CHEMICAL COMPANY ONE MILE RADIUS

EBASCO SERVICES INCORPORATED



R RESIDENCES
---- VICHEM PROPERTY BOUNDARY
LL LINED LAGOON
UL UNLINED LAGOON

0 100 200 300
SCALE IN FEET

TOPOGRAPHIC BASE PREPARED FOR U.S. ARMY CORPS OF ENGINEERS BY KUCERA INTERNATIONAL, JANUARY 1986.

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1-4

VINELAND CHEMICAL COMPANY SITE PLAN

EBASCO SERVICES INCORPORATED

TABLE 1-1

CHEMICALS USED, MANUFACTURED OR STORED AT
VINELAND CHEMICAL PLANT

METALS AND INORGANIC SALTS

Arsenic
Mercury
Mercury (II) Chloride
Mercury (I) Chloride
Cadmium
Cadmium Chloride

METAL ORGANICS ARSENIC COMPOUNDS

Disodium methane arsonate
Dodecyl and octyl ammonium methane arsonate
Monosodium acid methane arsonate
Calcium acid methane arsonate
Dimethylarsinic acid (Cacodylic acid)

ORGANIC MERCURY COMPOUNDS

Phenyl mercury dimethyldithio carbonate
Phenyl mercury acetate

HERBICIDES

Sodium 2,4-dichlorophenoxy acetate (2,4D)
2,4-dichlorophenoxy acetic acid
2,4-chloro-2-methyl phenoxy propanoic acid (MCPP)

bis(dimethylthio-carbonoyl) disulfide (thiram)

1,4-bis(bromoacetoxy)-2-butene
2,3-dibromopropionaldehyde

Alkylarylpolyether alcohol

TABLE 1-1 (Cont'd)

CHEMICALS USED, MANUFACTURED OR STORED AT
VINELAND CHEMICAL PLANT

SOLVENTS AND GENERAL ORGANIC CHEMICALS

Benzyl alcohol	Trichloroethane
Xylene	Trichloroethylene
2,3 Benzo furan	Methylene-bis-thiocynate
Methylene Chloride	Hydrobromic acid
Methanol	Butorfdiol
Epichlorohydrin	Ethylene Glycol
Acrolein	Tetrachloroethylene
Isopropyl alcohol	Bromochloromethane
Glycerine	Tetrabutyl ammoniumbromide
Triton X-100	Gasoline
Formaldehyde	Kerosene

POSSIBLE CHEMICALS FROM MANUFACTURING

Phenol
Chlorophenols
Chloroacetic acid
Chlorides
Arsenic Trioxide
Methyl chloride
Methanol
Sodium hydroxide
Calcium oxides
Mercury oxides

The wastewater treatment system consists of mix tanks, a reactivator, filters and ancillary equipment. Ferric chloride is added to the first flash mix tank and caustic soda is added to the second mix tank to promote flocculation. The wastewater then enters the reactivator where it is mixed with a polymer. This mixture passes through a flocculation compartment where the large particles settle to the bottom and are removed to a rubber-lined tank. The reactivator effluent is polished by a tertiary filter before discharge. The slurry in the rubber-lined tank is pumped into a vacuum filter and the dry solids are deposited in a dumpster for off-site disposal. Any liquid not meeting discharge requirements is reportedly recirculated for treatment.

The treatment system is designed to produce an effluent arsenic concentration of 0.05 mg/l. However, the NJDEP determined that the effluent arsenic concentration from the treatment system was consistently greater than 0.7 mg/l. Therefore, the NJDEP has initiated actions to deny the pertinent New Jersey Pollutant Discharge Elimination System (NJPDES) and RCRA Part B permits.

ViChem reports that it no longer treats either groundwater or process water. Reportedly all of the water used in manufacturing the herbicides is consumed by the process and is included as inherent moisture in the product. ViChem ceased pumping and treating groundwater in July, 1987 with the consent of the NJDEP. The wastewater treatment plant now reportedly treats only stormwater runoff on an intermittent basis.

The herbicide manufacturing process produces approximately 1,107 tons of waste by-product salts each year. These wastes have an USEPA hazardous waste number of K031 and are neither treated nor disposed of at the site, nor stored on-site for more than 90 days. The salts are transported by licensed shippers to licensed facilities in Ohio and Michigan for disposal.

1.2.2 Site History

ViChem began manufacturing organic arsenical herbicides and fungicides at this plant in approximately 1949. In addition to arsenical herbicides, the company also produced cadmium based herbicides and used other inorganics such as lead and mercury. Table 1-1 presented a list of chemicals used, manufactured, or stored at the ViChem plant.

In 1978, the NJDEP investigated a reported spill from the site into the Blackwater Branch. The NJDEP determined that waste salts from herbicidal production were improperly stored in large piles on the site. These salts reportedly contained one to two percent arsenic (RCRA Part B Permit Application, 1980). The NJDEP also determined that untreated process water containing arsenic was being discharged into the lagoons and allowed to infiltrate into the groundwater.

Precipitation which came in contact with the waste salt piles dissolved the salts and carried an unknown quantity of arsenic into the subsurface groundwater. Untreated process water was discharged into the unlined lagoons on site, and an unknown quantity rapidly infiltrated into the groundwater.

In response to a series of Administrative Consent Orders issued by the NJDEP, ViChem instituted some clean-up actions and modified the production process. The clean-up actions included stripping the surface soils in the manufacturing area, piling these soils in the clearing by well cluster EW-15, and paving the manufacturing area; installing a stormwater runoff collection system; removing the piles of waste salts; and installing a groundwater pump and treatment system, including the wastewater treatment plant. Modifications to the production process included installing a closed water system, lining two of the lagoons used in the wastewater treatment system, and properly disposing of the waste salts.

Despite these efforts, evidence suggested that a serious groundwater contamination problem existed at the ViChem site, and that the groundwater was discharging into the streams and degrading the downstream water quality. Therefore, this RI/FS was undertaken to investigate the extent of the groundwater contamination and to evaluate remedial alternatives for rehabilitating the groundwater at the plant site and in downstream sediments and surface waters, including Union Lake.

1.2.3 Previous Investigations

Since 1978, a number of studies have been performed by or for the NJDEP Office of Science and Research in the Maurice River watershed and at the ViChem plant site. ViChem itself has also conducted some investigations into the groundwater plume at the plant.

In 1979-1980, the NJDEP initiated a sampling program in the Blackwater Branch and the Maurice River downstream from the site. The results showed that the sediment arsenic concentrations in the Maurice River were the highest seen anywhere within the state of New Jersey. The study showed that the Almond Beach weir, the submerged dam in Union Lake, the lower main dam in Union Lake, and the tidal creeks of the Maurice River estuary below Union Lake stored arsenic contaminated sediments. Elevated arsenic concentrations were found in sediments as far from the site as the Delaware Bay. Also, the arsenic concentration in the surface water decreased downstream from the site but did not reach the Federal Primary Drinking Water Standard for arsenic, 0.05 mg/l or 50 ug/l, until 26.5 river miles downstream from the ViChem site.

In 1981, the NJDEP performed a surface geophysical survey of the plant area. The study identified two areas of probable groundwater contamination, one northwest of the lagoons toward the Blackwater Branch and the other near the former outdoor storage area. The study estimated that the probable maximum depth of the contaminant plume was approximately 40 feet.

In 1982, ViChem commissioned a groundwater investigation of the site. In this study previous investigations were reviewed and a scheme to remove arsenic from the contaminated aquifer was proposed. This study included several sets of water quality data. Approximately 4 1/2 years of monthly arsenic concentrations at ViChem well MW-1 were presented along with data from ViChem wells MW-6 and MW-10. This data showed a marked drop in the arsenic concentration in the groundwater between 1978 and 1981. The study also presented monthly levels of arsenic in the Blackwater Branch at Mill Road, and in the Maurice River at the Almond Road weir. The study postulated that the arsenic load at Mill Road was very similar to the arsenic load at Almond Road, implying that the river system was essentially a conduit for arsenic transport into Union Lake. The study reviewed processes for arsenic clean-up at the site and recommended a groundwater pump and treatment program along with controlled soil leaching.

Two studies of Union Lake were conducted by the NJDEP and Rutgers University from 1980 to 1982. The studies showed that Union Lake was chemically stratified during the summer. This stratification created seasonal anaerobic conditions in the bottom sediments, which were conducive to the formation of toxic arsenical compounds from the contaminated sediments (NJDEP, 1980). The Rutgers University work included sampling and analysis of water and sediments, as well as speciation of arsenic [trivalent As (III), pentavalent As (V), monomethyl arsenic acid (MMAA) and dimethyl arsenic acid (DMAA)(Faust, 1983)]. This study concluded that the waters and bottom sediments were highly contaminated with substantial quantities of arsenic, and that total arsenic concentrations in all lake water samples exceeded the NJDEP and USEPA drinking water standard of 50 ug/l. In sediments, the order of predominance of the four arsenic species (in descending order) was: As (V), As (III), MMAA, DMAA. In four of the sediments, the inorganic arsenate was between 73% and 88% of the total arsenical species. In water, the order of predominance was MMAA, As (III), As (V), and DMAA. The results of the resampling efforts revealed a seasonal pattern of arsenic concentrations within the lake water with the greatest concentrations occurring during the summer. Additional NJDEP sediment sampling near the spillway area of Union Lake in April, 1986 again showed arsenic contamination within the sediments and showed that the contamination was a surficial phenomenon.

In a 1983-1985 study by Rutgers University (Winka, 1985), it was shown that arsenic may exist in many species in the watershed, and that these species may be transformed by changes in physical condition and season. Results indicated that within the water column the inorganic arsenic species may be one half of the total arsenic. Arsenic was not easily solubilized under aerobic conditions. The concern raised by these findings is that when an anaerobic condition develops on the bottom of Union Lake, the arsenic may be readily converted into the more toxic forms. The more toxic forms could then be released to the water column upon seasonal turnover of the stratified layers. However, as these compounds are extremely insoluble, they were expected to precipitate back to the lake bottom within a relatively short period of time.

In addition to the above studies, Ebasco under contract with the USEPA, prepared RI reports for the ViChem plant site (Ebasco, 1988a) and the River Areas (Ebasco, 1988b). The pertinent findings of these RI's relative to Union Lake are as follows:

- There is a heavily contaminated arsenic plume in the groundwater underneath the ViChem plant site. The arsenic contaminated groundwater discharges into the Blackwater Branch, and is distributed downstream in the basin. The estimated present-day load of arsenic entering the Maurice River system from the ViChem plant site is approximately 6 metric tons per year. Through time, an estimated 500 metric tons of arsenic had been discharged into the Blackwater Branch. This arsenic has been distributed downstream in the Maurice River system, including Union Lake.

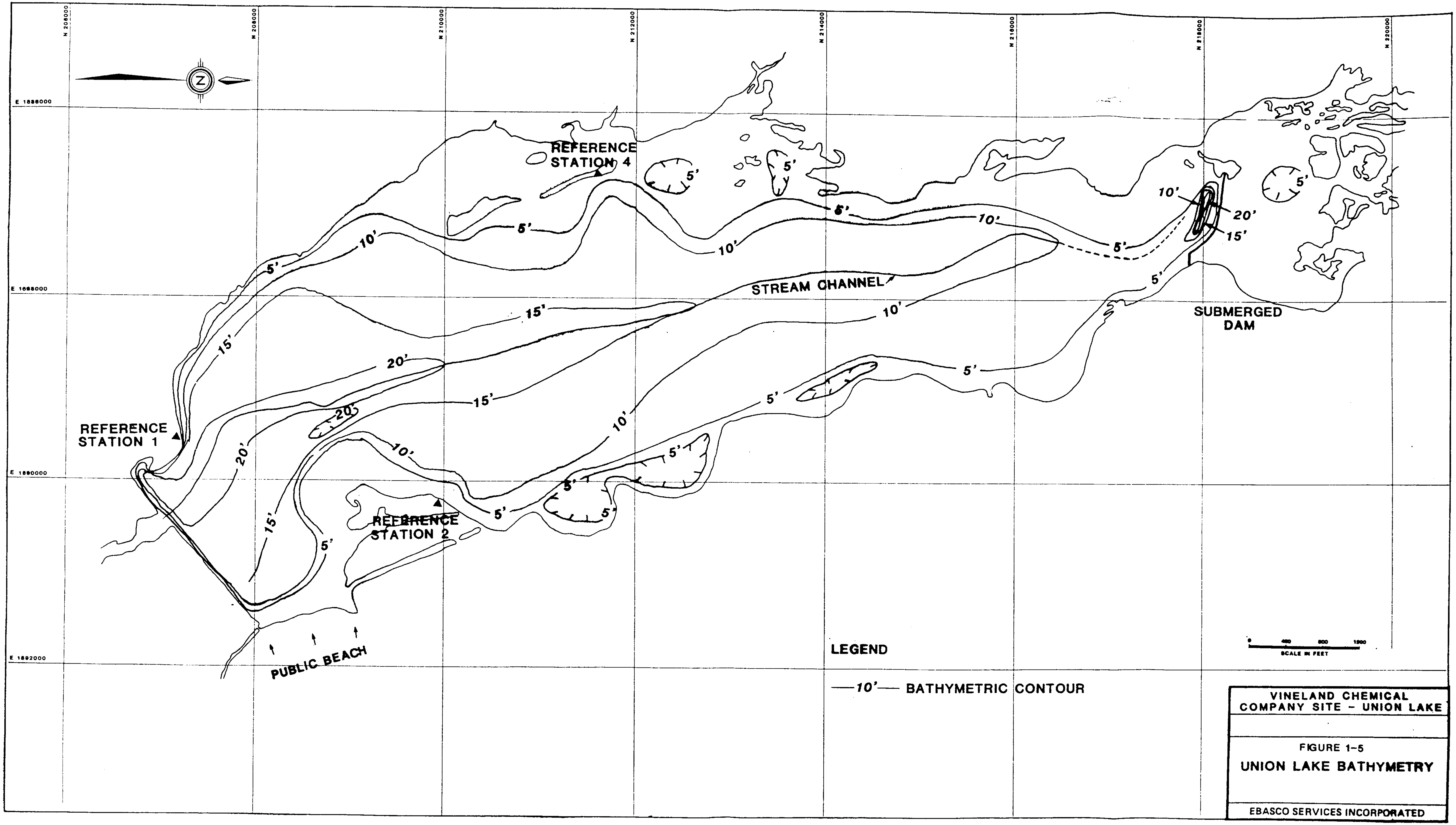
- The Blackwater Branch and the Upper Maurice River basically behave as conduits, transferring the arsenic that comes off of the plant site downstream in the drainage basin. There are pockets of contaminated sediments upstream of the lake, particularly in the formerly flooded region of the Blackwater Branch adjacent to the ViChem plant.

1.3 SUMMARY OF THE RI REPORT

The draft RI report for Union Lake was submitted to the EPA in June, 1988. The major findings of the RI as they relate to this FS are summarized below.

1.3.1 Physical System

A bathymetric survey of the lake was performed for the RI. Bathymetric contours are shown in Figure 1-5. The lake is



VINELAND CHEMICAL COMPANY SITE - UNION LAKE

FIGURE 1-5

UNION LAKE BATHYMETRY

EBASCO SERVICES INCORPORATED

typically shallow, especially at the upstream northern end. There is a submerged dam at the northern end of the lake. A relatively deep hole exists just downstream of this submerged dam, as shown in Figure 1-5.

The main dam at the southern end of the lake is currently undergoing reconstruction. The dam was assessed to pose a safety hazard because the spillway was inadequate to pass the probable maximum flood (PMF) resulting from various rainfall events.

Prior to the reconstruction project, the lake's normal pool elevation was approximately 27 feet MSL. The actual pool elevation varied according to flow. The estimated flow out of the lake is 325 cfs (experienced 50% of the time), which produced the 27 feet MSL pool elevation.

To facilitate the dam rehabilitation, a section of the spillway was breached to lower the lake's water level. The breached section has a bottom elevation of approximately 16 feet MSL. The depth of water flow over the breached section is approximately 2.2 feet at the median 325 cfs flow, resulting in a normal pool elevation of approximately 18.2 feet MSL. Therefore, the lake's elevation has been lowered between 8 and 9 feet for reconstruction.

The new spillway will be approximately 200 feet wide and will have a bottom elevation of 26.67 feet MSL. At the median flow of 325 cfs, the lake's pool elevation will be approximately 27 feet MSL. Six new low level outlets will be provided, three at an elevation of 16 feet and three at an elevation of 11 feet MSL. The outlets can be used to pass high flows or to artificially lower the lake's water level if desired.

The NJDEP's Division of Fish, Game, and Wildlife is the using agency for the reconstruction project and will control the operation of the spillway. They can lower the water level, for example, if they decide to control bottom growth through partial draining to expose bottom areas, thus allowing vegetation to freeze and die before refilling the lake.

Detailed studies of the lake's inflow versus its outflow have not been performed. However, PRC Engineers, the company performing the dam reconstruction project, estimates that the lake outflow is approximately twice the flow volume at the USGS gaging station on the Maurice River at Norma, approximately 4 miles upstream.

The lowest flow recorded at Norma since the gage began operating in 1932 is 23 cfs. Since there has always been recorded flow at the Norma gage, and since it is believed that the Maurice River is an effluent stream (recharged by groundwater), it is assumed unlikely that even prolonged droughts would cause a lowering of the lake's water level below the spillway.

There is very little groundwater information available in the vicinity of Union Lake for determining if the lake could impact local groundwater supplies. However, the City of Millville derives its municipal groundwater supply from 7 wells. All of these wells are at least one mile away from the lake. Millville's water system is periodically tested for arsenic and levels have been acceptable.

1.3.2 Nature and Extent of Contamination

The sediment in Union Lake is contaminated with arsenic and is extremely heterogeneous in physical and chemical composition. The percent of sand and silt varied greatly between samples collected in close proximity to one another. Similarly, the arsenic concentrations in collected samples varied by orders of magnitude.

Arsenic contamination, as evidenced by the core sample analytical results, is a surficial phenomena, present in the first one foot of the Union Lake sediments. Concentration levels ranged from not detected to 1,273 ppm, with the greatest levels occurring within the northern portion of the lake. Figure 1-6 presents the results of sediment samples taken by the NJDEP and Ebasco in 1986.

The results of the Union Lake water sampling are shown in Table 1-2. The analyses indicated that trace metals were usually present only in the water samples collected at the bottom of the water column, at the sediment-water interface. This suggests that these metals are associated with resuspended bottom sediments. The lake water contains total arsenic in the range of 10 to 190 ug/l distributed almost evenly among the upper-lake, mid-lake and lower-lakes, particularly for the dissolved arsenic in the range of 10 to 80 ug/l. The mean total arsenic concentration, approximately 56 ug/l, is slightly above the Federal Primary Drinking Water Standard for arsenic, 50 ug/l.

The arsenic concentration in the Union Lake water apparently exhibits seasonal fluctuations. The greatest concentrations occur in summer and early fall, and the lowest concentrations occur in winter. This seasonality in arsenic concentrations is supported by several studies. Resuspended lake sediment can cause elevated arsenic concentrations, particularly close to the bottom and in highly turbid areas of the lake (i.e., adjacent to where the Maurice River enters the northern portion of the lake).

The results of the fish analyses are presented in Table 1-3. Among the fish caught, chlordane (5-72 ppb), DDE (63-160 ppb), PCB 1260 (120-400 ppb) and arsenic (20-240 ppb) were found to be present. The results indicate that the greatest concentrations of each chemical compound were generally present within bottom

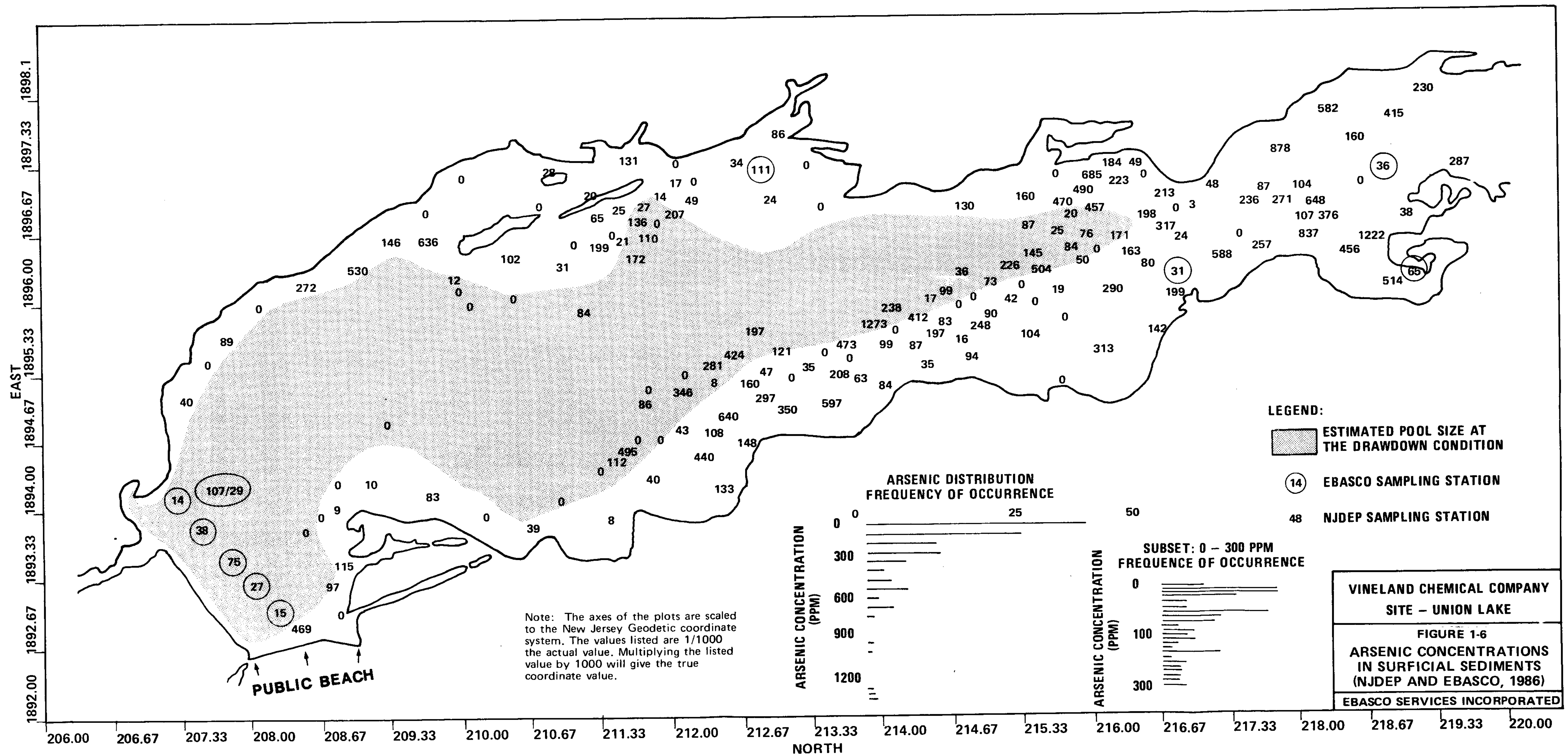

LEGEND:
ESTIMATED POOL SIZE AT THE DRAWDOWN CONDITION
14 EBASCO SAMPLING STATION
48 NJDEP SAMPLING STATION
ARSENIC DISTRIBUTION FREQUENCY OF OCCURRENCE
SUBSET: 0 – 300 PPM FREQUENCE OF OCCURRENCE
ARSENIC CONCENTRATION (PPM)
PUBLIC BEACH
EAST
NORTH
Note: The axes of the plots are scaled to the New Jersey Geodetic coordinate system. The values listed are 1/1000 the actual value. Multiplying the listed value by 1000 will give the true coordinate value.
VINELAND CHEMICAL COMPANY
SITE – UNION LAKE
FIGURE 1-6
ARSENIC CONCENTRATIONS IN SURFICIAL SEDIMENTS (NJDEP AND EBASCO, 1986)
EBASCO SERVICES INCORPORATED

TABLE 1-2

VINELAND CHEMICAL COMPANY SITE
CONCENTRATION RANGES (mg/kg) OF TOTAL
ARSENIC LEVELS IN
UNION LAKE SEDIMENT SAMPLES

	Total As
NJDEP SAMPLING (August, 1986)	
Lakeshore sediments in less than 10 feet of water (193 sample locations)	0 - 1273
PHASE I (June - July, 1986)	
Upper Lake sediment (EL-1, EL-2)	36 - 65
Mid-Lake sediment (EL-5)	12
Lower Lake sediment (EL-9 through 13)	14 - 107

TABLE 1-2 (Cont'd)

VINELAND CHEMICAL COMPANY SITE
CONCENTRATION RANGES (ug/l) OF TOTAL AND
DISSOLVED ARSENIC LEVELS
IN UNION LAKE WATER SAMPLES

	Dissolved As	Total As
Particulate As		
NJDEP (September, 1982-1983)		
Upper Lake water	-	36 - 267
Mid-Lake water	-	27 - 100
Lower Lake water	-	33 - 194
PHASE I (June - July, 1986)		
Upper Lake water (EL-1, EL-2)	44(R) - 50(R)	65(R) - 66(R)
Mid-Lake water	48 - 67	54 - 81
Lower Lake water (EL-9 through EL-13)	48 - 75	54 - 81
PHASE II (January, 1987)		
Upper Lake water (EL-28 through EL-30)	21 - 41	20 - 187
Mid-Lake water	10 - 22	11 - 26
Lower Lake water (EL-9 through EL-13)	14 - 16	12 - 126

(R) - Rejected value

feeding (i.e., catfish) and piscivorous species (i.e., pickerel). These results are consistent with similar studies of pesticide/PCB's and/or metal residues within fish muscle tissue performed elsewhere (Reference 8). The duplicate sample results show that the precision of the analytical results was very good.

1.3.3 Contaminant Fate and Transportation

Arsenic is mobile in the environment. Both natural and man-made arsenic can be cycled within the air, water, and soil by mechanisms such as oxidation/reduction, adsorption/desorption, precipitation/dissolution, and biological methylation and demethylation. The arsenite (+3) form of arsenic is four to ten times more soluble in soil (and probably sediment) pore water than is the arsenate (+5) species. Arsenic can form insoluble precipitates with calcium, sulfur, iron, aluminum and barium compounds in natural waters. The partitioning of arsenic between natural waters and sediments may be controlled by both precipitation and adsorption processes. Aqueous speciation of arsenic is also controlled by biological methylation and demethylation.

Arsenic was transported to Union Lake from the upstream by suspended particle dispersion, solute adsorption onto the sediment, and "entrapment" in adsorbed solute as heavier sediment particles are left behind. For sediments in Union Lake, the following order with respect to decreasing concentrations of fractions was found :

$As^{+5} > As^{+3} > MMAA > DMAA$.

In water, the order of predominance was found to be:

$MMAA > As^{+3} > As^{+5} > DMAA$.

The observed dominance of the arsenate (+5) species in the predominately reduced sediments may be due to the fact that arsenic was originally adsorbed onto the sediment particulate matter under more oxidizing conditions in the upstream and it was subsequently deposited in the sediments.

The ViChem plant was shown to be the only significant source of arsenic to the Maurice River drainage basin. All river sections downstream from the site showed elevated levels of arsenic in both water and sediments. The levels of arsenic in all of the other tributaries studied were very low to undetected. Small sources below the Union Lake Dam cannot be ruled out but no evidence exists for any inputs.

TABLE 1-3

VINELAND CHEMICAL COMPANY SITE
ARSENIC, PESTICIDE AND PCB RESULTS
FOR FIVE FISH SPECIES (ug/kg)
(January, 1987)

Organism	Chlordane	4,4'-DDE	Arochlor 1260	Arsenic
Catfish species 1 (*Ictalurus sp.*)	72	160	400	220
Catfish species 2 (*Ictalurus sp.*)	54	89	200	110
Sucker (family catostomidae)	32*	63	120	20**
Sunfish (*Lepomis sp.*)	5*	-	-	20
Pickerel (*Esox sp.*)	7*	-	-	240
	7*(d)	-(d)	-(d)	190(d)

-   - Not detected

*   - Below detection limit

NA - Not applicable or available

** - Less than concentration listed

(d) - Duplicate sample result for *Esox sp*

Based on samples collected by ViChem at Mill Road, an estimated 500 metric tons of arsenic has been transported past Mill Road into the Blackwater Branch and upper Maurice River through time. Instantaneous flux measurements by a number of investigators agree with the historic trend at Mill Road and indicated that the flux from the site was 4 to 8 metric tons/yr in 1987. These fluxes were confirmed by cross checking Ebasco, USGS and ViChem data. Arsenic was transported in the basin in both dissolved and suspended forms. Arsenic concentrations varied throughout the year, inversely correlating with water flow.

Arsenic concentrations in the sediments of the Blackwater Branch and upper Maurice River positively correlated with total organic carbon content, iron content and percent clay. These data suggested that arsenic was bound to the sediments via organic carbon and ferric hydroxide matrices which coat the finer sediments fractions. Leach tests of Union Lake sediments by Winka (1985) showed that 50 to 70% of the sediment bound arsenic was not easily extractable. The fraction retained correlated positively with percent organic matter. Limited data is available within the lake to corrolate arsenic in the sediments with grain size or organic matter, however it is believed that the same positive correlation exists that was seen in the river sediments.

The total inventory of arsenic in the lake sediments was calculated from the NJDEP and Ebasco sediment samples. A data gap exists in that most of the sediment samples were taken from shallow areas (less than 10 feet deep) and only limited sampling was conducted in deeper portions of the lake. Nevertheless, the total quantity of arsenic bound to the lake sediments was estimated to be approximately 150 metric tons, or approximately one-third of the arsenic released off of the site through time.

The Blackwater Branch and upper Maurice River appeared to be simple conduits for arsenic released from the site based on the arsenic mass balance for 1987 and the low inventory of arsenic in the sediments. The effect of Union Lake on the present arsenic balance was unclear. Mass balance calculations showed it to be a simple conduit. However, sediment-water equilibria show that the lake water and sediments were near equilibrium. Given these conflicting mechanisms, the present fate of arsenic in the lake was not predictable. The large inventory of arsenic in the lake sediments showed that the lake has been a major sink for arsenic in the past. In view of the low river sediment loads, the lake is most likely the final depository for much of the arsenic.

Future arsenic levels in the lake are difficult to predict even if the arsenic flux from the site is eliminated since it is unclear what controls the lake's water arsenic concentration, the inflow concentration or sediment desorption. Almost certainly the water arsenic concentrations would decrease if the upstream source is eliminated, but the magnitude and rate of decrease cannot be predicted until more is known about the rate of arsenic desorption off of the sediments.

1.3.4 Risk Assessment

A semi-quantitative risk assessment was performed using the basic methodology in the Superfund Public Health Evaluation Manual, and incorporating extensive input from the EPA's Office of Health and Environmental Affairs (OHEA), the NJDEP, and EPA Region II personnel.

Risks were modeled in a "worst-case" basis, using worst-case exposure assumptions and maximum contaminant concentrations, and on a "most plausible" basis, using more plausible exposure assumptions and mean contaminant concentrations. Stayed adult models were prepared, integrating risks over a lifetime as opposed to simple child/adult models.

Risks were calculated for the lake at its full condition; for the lake drawdown for periods of three and five years while institutional controls limited site access; and for the lake drawndown for three years when no institutional controls limited site access. The first case, lake full, was performed to determine the risks from the lake at its full condition. The second, assuming drawdown and institutional controls, was performed to model the risks which could occur as a result of dewatering the lake for construction and limiting public access to exposed, potentially contaminated sediments. The last, drawdown with no institutional controls was performed to simulate a possible drought condition or a failure of the institutional controls to prevent public access to exposed sediments.

Exposures were calculated for recreational usage of the lake such as swimming, boating, fishing and playing. The lake is a popular recreational area where all of these activities are known to occur during the warm season.

Arsenic was found to be the main contaminant of concern. The risk calculations from exposure to arsenic in the lake sediments, water, and fish are presented in Tables 1-4 and 1-5. The risks may be summarized as outlined below.

- o Sediments

Two exposure pathways were considered, inhalation of the exposed sediments and accidental ingestion of the sediments. Ingestion was considered for sediments under very shallow water or sediments exposed at the water's edge.

TABLE 1-4

SUMMARY OF CANCER RISKS FOR EXPOSURE PATHWAYS
AT UNION LAKE

Pathway	Estimated Lifetime Cancer Risks	
	Most Probable	Worst Case
Exposure Sediment Ingestion	6×10^{-6}	7×10^{-4}
Lake Water Ingestion	6×10^{-6}	4×10^{-5}
Lake Water Dermal Contact	1×10^{-7}	7×10^{-7}
Total for Recreational (non-fishing) Exposure	1×10^{-5}	7×10^{-4}
Exposure Sediment Inhalation (drawdown or drought)	1×10^{-8} 2×10^{-8}*	2×10^{-6} 3×10^{-6}*
Fish Ingestion	2×10^{-4}	2×10^{-3}

* Risks for three-year drawdown/risks for five-year drawdown.

TABLE 1-5

ARSENIC CANCER RISKS FROM UNION LAKE
FOUR SCENARIOS OF LAKE CONDITIONS

WORST CASE	SEDIMENT	WATER	INHALATION	TOTAL
Scenario 1				
Normal Lake 70 Years	7×10^{-4}	4×10^{-5}	0	7×10^{-4}
Scenario 2				
Normal Lake 67 Years	7×10^{-4}	4×10^{-5}	0	7×10^{-4}
Construction 3 Years	0	0	2×10^{-6}	
Scenario 3				
Normal Lake 65 Years	7×10^{-4}	4×10^{-5}	0	
Construction 5 Years	0	0	3×10^{-6}	7×10^{-4}
Scenario 4				
Normal Lake 64 Years	6×10^{-4}	4×10^{-5}	0	
Construction 3 Years	0	0	2×10^{-6}	
Drought Condition 3 Years	3×10^{-5}	2×10^{-6}	2×10^{-6}	7×10^{-4}
MOST PROBABLE CASE:				
Scenario 1				
Normal Lake 70 Years	6×10^{-6}	6×10^{-6}	0	1×10^{-5}
Scenario 2				
Normal Lake 67 Years	6×10^{-6}	6×10^{-6}	0	
Construction 3 Years	0	0	2×10^{-8}	1×10^{-5}
Scenario 3				
Normal Lake 65 Years	6×10^{-6}	6×10^{-6}	0	
Construction 5 Years	0	0	3×10^{-8}	1×10^{-5}
Scenario 4				
Normal Lake 64 Years	5×10^{-6}	5×10^{-6}	0	
Construction 3 Years	0	0	2×10^{-8}	
Drought Condition 3 Years	3×10^{-7}	3×10^{-7}	2×10^{-8}	1×10^{-5}

Inhalation risks were very low, approximately 1 x 10^{-8} or one incident of cancer per one hundred million people exposed, via the most plausible exposure assumptions. The worst case risks were also very low, 2 to 3 x 10^{-6} or two to three incidents of cancer per one million people exposed. These calculations assumed that the lake was drawndown for three or five years as explained above.

The sediment ingestion risks were higher, 6 x 10^{-6} for the most plausible exposure assumptions and 7 x 10^{-4} for the worst case assumptions. This pathway is considered valid only for sediments under very shallow water, approximately two and one-half feet deep or less, near the lake shore where activities such as playing and splashing could result in accidental sediment ingestion. In deeper water, the intimate kind of sediment contact which could result in sediment ingestion is considered unlikely. While older children and adults could conceivably stand on sediments in water deeper than two and one-half feet, it is considered unlikely that they would ingest sediments covered by this depth of water.

- <u>Lake Water</u>

Lake water risks were calculated for two pathways, dermal contact during recreation and accidental ingestion during recreation. The risks were not calculated for using the lake as a water source. As mentioned, the mean total arsenic concentration of the lake is above the Federal Primary Drinking Water Standard for Arsenic.

The calculated risks for lake water dermal contact were very low, 1 x 10^{-7} and 7 x 10^{-7} for the most plausible and worst-case assumptions, respectively. This is in part a result of the estimated small percentage of arsenic (six to twelve percent) which is absorbed through the skin.

The accidental water ingestion risks were somewhat higher, 6 x 10^{-6} for the most plausible case and 4 x 10^{-5} for the worst case assumptions.

- <u>Fish Ingestion</u>

Fish ingestion risks are summarized in Table 1-6. This table shows that the bulk of the risk from fish ingestion are from the PCBs which were detected at low concentrations in the fish samples. The calculated risks from arsenic in the fish comprised approximately 10% of the risk from this pathway.

As pointed out in the RI, the fish ingestion risks from arsenic may be overstated. This is because it was assumed in the risk assessment that the arsenic in the fish was a combination of As (III) and As (V). Other studies suggest that the arsenic in fish is probably present in a relatively less toxic organic form which can easily pass through the body.

TABLE 1-6

CONTAMINANT INTAKE AND CANCER RISK ESTIMATES FOR UNION LAKE FISH INGESTION PATHWAY

CONTAMINANT	MOST PROBABLE CASE		WORST-CASE	
	CDI*	CANCER RISK	CDI*	CANCER RISK
ARSENIC	1.3×10^{-5}	2×10^{-5}	1.4×10^{-4}	2×10^{-4}
CHLORDANE	2.9×10^{-6}	4×10^{-6}	4.3×10^{-5}	6×10^{-5}
DDE	1.0×10^{-5}	3×10^{-6}	9.5×10^{-5}	3×10^{-5}
PCBs	2.3×10^{-5}	2×10^{-4}	2.4×10^{-4}	2×10^{-3}
TOTAL	-	2×10^{-4}	-	2×10^{-3}

* mg/kg-day

The PCB's found in the fish are not believed to be related to the ViChem site. The ViChem plant has no history of PCB use, production, or disposal. PCB's have a high bioconcentration factor, so small amounts in the water can produce detectable concentrations in fish. PCBs also have a high Kd, meaning that they preferrentially adhere to soils and sediments rather than desorbing off into the water column. While the water and sediments in Union Lake were not analyzed for PCBs, several samples were taken in the Blackwater Branch and the Maurice River upstream from the lake. PCBs were detected only sporadically at low concentrations.

1.3.5 Recommended Remedial Action Objectives

The source of the arsenic contamination in Union Lake is the groundwater discharge off of the ViChem plant site. Before any remedial action in the rivers or lake downstream of the site are taken, this source should be eliminated.

The lake is now drawn down to facilitate dam reconstruction. It is expected that construction will be complete and that the lake will be refilled by June of 1990. Because of the likely timing of remedial actions at the site, with upstream actions being taken prior to downstream actions, it is unlikely that any remedial action in the lake could be taken until after the lake has been refilled. Therefore, the EPA has directed that remedial alternatives for the lake be considered with the lake at its full condition.

Accidental ingestion of the lake water during recreational activities could pose slightly increased health risks. The total arsenic concentrations in the lake currently exceeds Federal standards for drinking water and New Jersey standards for fresh water body. However, it is not certain what controls the lake water arsenic concentration - the incoming water or desorption off of the lake sediments. Because of this uncertainty, and because of the impracticality of treating the approximately 2.7 billion gallons of water in the lake discharging at a median rate of 350 cfs, remedial alternatives for the lake water are not presently being considered. The water quality can be monitored as the groundwater discharge off of the ViChem site is eliminated to see if this action is sufficient to improve the lake water arsenic concentration.

Potential health risks were calculated from ingesting fish from Union Lake. However, the risks from the arsenic in the fish may have been overstated. The present level of arsenic in the fish sampled was within USDA dietary standards for arsenic. The majority of the risks from fish ingestion were from PCBs which were detected at low levels. The source of the PCBs into the lake is not known since they were found only sporadically and at low concentrations in the sediments upstream from the lake. Because of the impracticality of remediating contamination already within fish, remedial alternatives were not considered for this pathway. The EPA may perform additional sampling to clear up the uncertainties in this exposure pathway in the future.

The risk from inhaling exposed sediments were very low, however the risks from accidential sediment ingestion during recreational activities in shallow water were found to be somewhat elevated. Using the mean sediment arsenic concentration and most plausible exposure assumptions, the risks were 6×10^{-6}, or a possible 6 incidents of cancer per one million persons exposed.

While the risk using the mean arsenic concentration is relatively low, there are "hot-spots", or areas of high arsenic concentrations in the lake. If people are exposed to sediments with high arsenic concentrations in shallow areas, the potential health risks could increase.

Table 1-7 presents calculations which show the estimated health risks which could occur at various sediment arsenic concentrations for sediments in shallow waters, less than approximately two and one half feet. This shows that a sediment arsenic concentration of 120 mg/kg produces a risk of 1×10^{-5}, or one incident of cancer per one-hundred thousand persons exposed.

Considering all of the above, the recommended remedial action objective for Union Lake is as follows:

- o Minimize public exposure, either through containment, removal, or institutional controls to areas with unacceptably high sediment arsenic concentrations.

This FS will concentrate on remedial alternatives for contaminated sediments under shallow water (less than two and one-half feet deep) in Union Lake.

TABLE 1-7

CALCULATED RISKS FROM SEDIMENTS
AT VARIOUS ARSENIC CONCENTRATIONS

Calculated Risk[1]	Sediment Arsenic Concentration (mg/kg)[2]	
	Most Probable Exposure Assumptions	Worst Case Exposure Assumptions
1×10^{-4}	1120	190
1×10^{-5}	120	19
1×10^{-6}	12	1.9
1×10^{-7}	1.2	0.19

1 Calculated Risks Assume Sediment Exposure Pathways Only

2 Contract Laboratory Program Contract Required Detection Limit for Arsenic in Soil/Sediment is approximately 2 mg/kg

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 INTRODUCTION

This section presents the development of the remedial action objective for the contaminated sediments and identifies and screens the most appropriate technologies to remediate the contamination.

The section describes a three-step process for identifying and screening potential technologies. First, the remedial action objective for the contaminated sediments is developed based on contaminant characterization, risk assessment and compliance with applicable or relevant and appropriate requirements (ARARs). Second, technology screening criteria are developed based on the remedial action objective, site-specific requirements and contaminant characteristics. General response actions, which address the site problems and meet cleanup goals and objectives, are identified. Third, potential technologies associated with each response action are identified and evaluated. The technology types are screened to determine those that are feasible or applicable to the site based upon the established criteria. The technologies that pass this screening are combined into remedial action alternatives for source control in Section 3.

In some cases, process options rather than individual technologies are evaluated to simplify the screening process. Process options are relatively similar or equivalent technologies that will achieve the same or a similar end result, or are closely related to one another. When a group of technologies is evaluated as a process option, this implies that the use of any of the technologies would be similar. This simplifies the technology screening process.

This section is comprised of three subsections:

- 2.2 Remedial Action Objective
- 2.3 General Response Actions
- 2.4 Identification and Screening of Technology Types and Process Options

2.2 REMEDIAL ACTION OBJECTIVE

The remedial action objective for Union Lake is to:

- o Minimize public exposure to sediments with unacceptably high arsenic concentrations, either through removal, containment, or institutional controls.

This objective was developed after considering all of the data from the RI and the risk assessment as discussed below.

2.2.1 Contaminants of Interest

As discussed in Section 7.1.1 of the Union Lake RI, a number of organic and inorganic contaminants were detected in Union Lake. Inorganics included arsenic, mercury and lead. Organics included Chlordane, 4,4 DDE and Arochlor 1260.

Arsenic is the main contaminant of concern. Arsenic was found in the sediments, surface water, and some fish samples. The calculated health risks from the other contaminants were found to be minimal. There was an elevated health risk calculated from ingesting fish as a result of PCBs. However as discussed in Section 1.0, it is believed that ViChem is not the source of the PCBs, and the level of PCBs detected was very low. Therefore arsenic contamination is the focus of this FS.

2.2.2 Allowable Exposure Based on Risk Assessment

The risk assessment considered a number of different exposure pathways, and a number of different scenarios whereby the lake would be at its full condition and would be drawn down for various lengths of time. The risk assessment also considered worst-case exposure scenarios and most plausible exposure scenarios. Maximum contaminant concentrations were used to calculate risks for the worst-case exposure scenario, while mean contaminant concentrations were used to calculate risks for the most plausible exposure scenario. The end result of the risk assessment was to develop a series of calculations that showed, for both the worst-case and most plausible exposure scenarios, the total risk from recreational use of the lake, the risk from recreational exposure to various media in the lake (sediment, surface water, fish), and the risks from different types of exposure to each medium (dermal contact, ingestion, inhalation). These calculations are presented in Section 1.3.3 of this report.

The risks from exposure to the sediments were the focus of this FS. Potential increased health risks were calculated for incidental ingestion of lake water, and for ingesting fish from the lake. However, remedial alternatives for these two media were not included in this FS for the following reasons:

Water

- It is impractical to treat the entire water volume within the lake, estimated to be approximately 2.7 billion gallons when the lake is at its full condition.

- There is a constant influx of arsenic into the lake water via arsenic in the water of the upper Maurice River entering the lake. The mean flow rate of the river entering the lake is at least 123 CFS, which is the mean flow of the Maurice River at the Norma gaging station approximately 4 miles upstream from the lake.

- The groundwater discharge of the ViChem plant, which is the source of arsenic into the Maurice River, should be eliminated prior to considering any remedial alternatives for the downstream water, including the water in the Maurice River and the water in Union Lake.

Fish

- There are no practical remedial alternatives to reduce arsenic concentrations already found in fish.

- The risk assessment assumed that the arsenic detected in the fish was a combination of As (III) and As (V) in the same proportion as was found in the studies used to determine the Cancer Potency Factor (CPF) for arsenic. In fact, other studies suggest that the arsenic found in the fish would be an organic form that is relatively nontoxic. The form of arsenic found in the fish samples was not determined, but may be determined in further studies by the EPA.

- The concentration of arsenic in the fish samples, approximately 1 mg/kg, is within safe dietary levels presently established by the USDA.

Allowable concentrations of arsenic in the sediments, considering human recreational exposure, were calculated from the risk assessment. The most plausible exposure pathway models were used to back calculate the health risks that would be produced at various arsenic concentrations. Then a target risk level was established, and the sediment arsenic concentration corresponding to the target risk level became the basis for the sediment remedial alternatives.

Three sediment exposure pathways were considered; inhalation while the lake was drawn down, dermal contact, and accidental ingestion. The most plausible risks calculated for each of these pathways are summarized below:

- Inhalation - This pathway is valid only when the lake is drawn down. Lake drawdown durations of three and five years were considered. The most plausible risk from this pathway is approximately $1x10^{-8}$, or one incident of cancer per one hundred million exposed persons. Because these potential risks were so low, no remedial alternatives were considered for this pathway.

- Dermal Contact - This pathway is valid for both drawn-down and lake full conditions. The most plausible risk from this pathway is $1x10^{-7}$, or one incident of cancer per ten million people. Because these potential risks were so low, no remedial alternatives were considered for this pathway.

- <u>Ingestion</u> - This pathway comprises the majority of the risk from the sediment exposure pathways. Using the mean arsenic concentration in the sediments, the present most plausible risk calculates to $6x10^{-6}$. However, there are hot spots, or areas of high contamination, in the lake at certain locations. Using the most plausible pathway models, a sediment arsenic concentration of 120 mg/kg corresponds to a risk of $1x10^{-5}$, or one incident of cancer per one hundred thousand people exposed to the sediments.

After reviewing this data, the EPA, in conference with the NJDEP, determined that the sediment target risk level should be $1x10^{-5}$. This establishes a sediment cleanup level of 120 mg/kg arsenic in the sediments. This is the sediment cleanup level that EPA directed be used for this FS.

The sediment ingestion pathway model assumes that individuals can be exposed to sediments in such an intimate fashion that they may accidentally ingest sediment. This requires that the individuals must be in very shallow water, near the shoreline, where heavy activities such as splashing and playing could allow for the accidental direct ingestion of sediments. For the purposes of this FS, and with EPA Region II and EPA Office of Health and Environmental Affairs (OHEA) concurrence, it was assumed that this type of contact could only reasonably occur when sediments were submerged under less than approximately 2.5 feet of water. If sediments were submerged under a greater depth of water than this, it is unreasonable to expect that activities leading to direct sediment ingestion would occur. Dermal contact with sediment could occur in waters less than 2.5 feet deep, however the risk assessment showed that dermal contact itself posed very little risk to potentially exposed populations.

The risk-based cleanup level established for the sediments in Union Lake required preventing public access to sediments containing greater than 120 mg/kg arsenic content that were submerged under less than 2.5 feet of water. The driving force for this cleanup level is the sediment ingeston pathway model, which is assumed to be reasonable for sediments submerged under shallow water. For the purposes of this FS, it is assumed that this pathway is invalid for sediments submerged under more than 2.5 feet of water.

The target cleanup risk, $1x10^{-5}$, is within the EPA guidance range of remediating to risks within the range of $1x10^{-4}$ to $1x10^{-7}$. The target risk level of $1x10^{-5}$ is also consistent with the allowable risk that the NJDEP determined existed at the Almond Road Beach on the upper Maurice River (NJDEP, 1988).

2.2.3 Allowable Exposure Based on ARARs

Lake Water

The following ARARs establish a 50 ug/l total arsenic concentration as the criteria/standards for drinking water, groundwater or surface water quality:

- o Safe Drinking Water Act MCLs
- o New Jersey Water Standards (N.J.A.C. 7:9-6.6) Groundwater Quality Criteria
- o New Jersey Water Standards (N.J.A.C. 7:9-4.14C) Surface Water Quality Criteria for FW2 Waters
- o New Jersey PDES (N.J.A.C. 7:14A-6.15) Maximum Concentration of Constituents for Groundwater Protection

In addition, the Clean Water Act Water Quality Criteria for Protection of Human Health established a 2.2 ng/l arsenic level for water and fish ingestion, which was later adjusted to 25 ng/l for water ingestion only.

As shown in Table 1-2, although the current upper lake water and lower lake water contain total arsenic exceeding ARAR criteria/standards, the dissolved arsenic concentrations of the lake water are very close to the 0.05 mg/l limit.

Lake Sediments

No federal or state ARAR's exist that establish a cleanup action level for contaminated soils and sediments. The NJDEP, which has a department guidance value for arsenic in soils, and the federal government, through the RCRA program, have established certain criteria by which a soil or sediment may be considered hazardous or non-hazardous.

The NJDEP's department guidance value for arsenic in soils is 20 mg/kg. However, the NJDEP stresses that this is a guidance value only and should not be used as a cleanup action level.

The RCRA program has established certain criteria by which a soil may be considered hazardous or non-hazardous. In the case of soils contaminated with arsenic, if the leachable arsenic concentration following a RCRA Part 261 Extraction Procedure (EP) Toxicity Test or Part 268 Toxicity Characteristic Leaching Procedure (TCLP) test exceeds 5 mg/l, the soil may be considered hazardous because it is "characteristic". Also, if a soil has been contaminated with arsenic as a result of contact with a listed hazardous waste, the soil is also considered a listed hazardous waste. In the case of the Union Lake sediments, the elevated arsenic concentrations are a result of the sediments being contacted by water containing arsenic derived from the listed hazardous waste number K-031. As a result of this, personnel from EPA's Site Policy and Guidance Branch, Hazardous Site Control Division (HSCD), have determined that the contaminated sediments shall be considered a listed hazardous waste for the purposes of disposal. This designation does not, however, establish a cleanup level based on the arsenic concentration.

In summary, no state or federal ARAR's exist to establish a cleanup level for the arsenic contaminated sediments in Union Lake. The cleanup levels and the areas requiring remediation were established as discussed above under risk-based cleanup levels.

2.2.4 Development of the Remedial Action Objective

If the human health risks, as well as the elevated concentrations of arsenic found in the sediment of Union Lake are to be reduced to acceptable levels, remedial action must be developed to address the following objective:

- Minimize public exposure to sediments with unacceptably high arsenic concentrations, either through removal, containment, or institutional controls.

The following discussions summarize the findings and criteria that form the basis for the remedial action objective.

Elevated arsenic concentrations were found in the lake's water and fish. As discussed above, it is impractical to treat the lake water because of the size of the lake, the magnitude of flow containing arsenic coming into the lake, and the necessity of eleminating the source of arsenic into the basin before remediating downstream contamination. Therefore remedial alternatives for the lake water were not considered. No remedial alternatives were considered for the fish in the lake because the detected arsenic concentrations were within USDA dietary guidelines and the form of arsenic in the fish may actually be relatively non-toxic.

Elevated arsenic concentrations were also found in the lake sediments. No federal or state ARAR's exist establishing a cleanup level for contaminated sediments. The risk assessments determined that accidental ingestion of sediments containing greater than 120 mg/kg arsenic in very shallow waters during recreational activities would produce an increased cancer risk of $1x10^{-5}$, or one incident of cancer per one hundred thousand exposed persons. Exposure to sediments through inhalation or dermal contact, regardless of water depth, posed an acceptably low risk.

The focus of this FS was to determine remedial alternatives for sediments containing greater than 120 mg/kg arsenic under less than 2.5 feet of water. The acceptable arsenic concentration in sediments, based on the risk assessment, is 120 mg/kg. The areas requiring remediation are those where the sediments are under approximately 2.5 feet of water or less, and the sediment arsenic concentration exceeds 120 mg/kg.

2.3 GENERAL RESPONSE ACTIONS

2.3.1 Criteria for Initial Screening of General Response Technologies

The number of general response actions and associated remedial technologies that were potentially applicable to Union Lake was quite extensive. The technologies on this list were screened based upon their ability to address the remedial response objective. The screening process was based upon a set of criteria relevant to the protection of public health and the environment as well as to site-specific conditions and the contaminants.

Guidance provided in the National Oil and Hazardous Substances Contingency Plan as revised November 20, 1985; EPA Guidance on Feasibility Studies under CERCLA, EPA Interim Guidance or Superfund Selection of Remedy (December 1986); EPA Interim Guidance for FY87 ROD's (July 1987); and EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (March 1988) were utilized along with the professional judgement of engineers performing the Feasibility Study.

2.3.2 Identification of General Response Actions

Based on the established remedial action objective, site conditions, and waste characteristics, a preliminary screening of potential general response actions was conducted. A list of general response actions typically considered for cleanup of hazardous waste sites is presented in Table 2-1. The general response actions listed in Table 2-2 were determined to be feasible for the site and would address the remedial objective. General response actions such as pumping and collecting contaminated groundwater, storing hazardous materials, providing an alternate water supply for the community, and relocating residents were judged as not applicable for this site.

The no action category involves activities that restrict public access (e.g., fencing) to contaminated areas and that monitor contaminant migration (e.g., monitoring wells). Continued monitoring of a contaminated medium over time will enable the determination of natural restoration rates occurring through natural attenuation and biodegradation.

TABLE 2-1

POTENTIAL GENERAL RESPONSE ACTIONS

1. No Action
2. Containment
3. Treatment and Disposal
    - Pumping (Wastewater)
    - Complete Removal (Contaminated Sediment)
    - Partial Removal (Contaminated Sediment)
    - On-Site Treatment (Sediment and Wastewater)
    - Off-Site Treatment (Sediment and Wastewater)
    - In-situ Treatment (Sediment and Wastewater)
    - Storage (Contaminated Sediment)
    - On-Site Disposal (Contaminated Sediment)
    - Off-Site Disposal (Sediment and Wastewater)

Containment actions include technologies that involve little or no treatment, but provide protection to human health and the environment by reducing the mobility of contaminants and risks to exposure. Examples of containment actions are covering waste deposits and controlling groundwater movement by using low permeability barriers or containment walls.

Treatment actions include solids treatment and associated wastewater treatment technologies that act to reduce the volume, mobility, and/or toxicity of contaminants. There are many soil treatment technologies that are effective for metals, including thermal vaporization/oxidation, extraction and fixation. Waste water treatment technologies include physical, chemical and biological treatment.

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

2.4.1 Identification, Screening and Evaluation of Technologies

The next step in the FS process consists of identifying the categories of remedial technologies associated with each response action that are applicable to the Union Lake site and determining the feasibility of achieving the remedial objective by using those technologies.

The remedial technology categories that are selected for initial screening are presented in Table 2-2.

The screening of remedial technologies is based on the remedial action objective, site-specific conditions, waste characterization and the extent of contamination. Waste characteristics include physical properties such as volatility, solubility and density; specific chemical constituents such as total organic carbon and metals; and properties that affect the performance of a technology. Site characteristics gathered during the RI are reviewed to identify conditions that may limit or favor the use of certain remedial technologies. Technologies whose use is clearly precluded by waste or site characteristics are eliminated from further consideration.

TABLE 2-2

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

SARA Remedial Categories	General Response Actions	Remedial Technologies
1. No Action	Monitoring	- Monitor and analyze sediment fish and lake water
	Migration Assessment	- Sediment Transport Modeling
	Restricted Access/ Use	- Fence access areas - Prohibit fishing, crabbing, swimming and water sports - Prohibit irrigation
	Public Awareness	- Post warning signs - Inform local officials and residents - Hold public meeting
2. Containment	Capping	- Clay cap - Synthetic membranes - Chemical sealants
	Covering	- Sand - Stone/gravel - Filter fabric
	Barriers	- Silt curtains - Dikes/piers - Sheet piling
3. Treatment and Disposal		
a. Sediment	Complete or Partial Removal	- Excavation (backhoe, bulldozer, front-end loader, dragline) - Mechanical dredging (clam shell, bucket loader, dipper, Souerman dredge, terra marine scoop)

TABLE 2-2 (Cont'd)

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

SARA Remedial Categories	General Response Actions	Remedial Technologies
3. Treatment and Disposal a. Sediment (Cont'd)	Complete or Partial Removal	- Hydraulic dredging (suction/ dustpan, cutterhead, hopper dredge, horizontal auger-cutter dredge) - Pneumatic dredging (Airlift, Nametech, Oozer, Pneuma)
	On-Site or Off-Site Treatment	- Incineration - Wet oxidation - Acidification/Alkalization - Chemical extraction/ recovery - Chemical fixation and solidification - Drying beds - Gravity thickeners - Sedimentation basin/ lagoon - Dehydro drying beds - Ultrasonic dewatering - Centrifuge - Filter press - Vacuum filter - Belt filter press
	In-Situ Treatment	- Extraction - Grout Injection - Vitrification
	On-Site or Off-Site Disposal	- Construct On-Site RCRA Landfill - Construct Off-Site RCRA Landfill - Existing Off-Site RCRA Landfill - Construct On-Site Non-Hazardous Landfill - Existing Off-Site Non-Hazardous Landfill - Construct Off-Site Non-Hazardous Landfill - Ocean Disposal - Deep Lake Disposal

TABLE 2-2 (Cont'd)

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

SARA Remedial Categories	General Response Actions	Remedial Technologies
3. Treatment and Disposal a. Sediment (Cont'd)		
b. Wastewater	Pumping	- Centrifugal pump - Sludge pump
	On-Site Treatment	- Flocculation/Precipitation - Biodegradation - Oxidation - Clarification - Filtration - Ion Exchange - Adsorption - Reverse osmosis - Neutralization/pH adjustment
	Off-Site Treatment	- POTW and Industrial treatment facilities
4. Transportation Technologies		- Truck - Pipeline - Barge

Several sources are used during the initial screening of technologies, including the following:

- o Remedial Action At Waste Disposal Site Handbook, EPA, June 1982.
- o Handbook For Evaluating Remedial Action Technology Plans, EPA, August 1983.
- o Review Of In-Place Treatment Techniques For Contaminated Surface Soils, Volume 1: Technical Evaluation, EPA, September 1984.
- o Technologies Applicable To Hazardous Waste, EPA, May 1985.
- o RCRA/CERCLA Alternative Treatment Technology Seminar, EPA, May 1986.
- o Handbook For Stabilization/Solidification Of Hazardous Wastes, EPA, June 1986.
- o Mobile Treatment Technologies For Superfund Wastes, EPA, September 1986.

In addition to these references, the annual proceedings of hazardous waste research symposia/conferences were used as sources of information (e.g., "Proceeding of Annual Research Symposia" published by EPA; and the "Conference on Management Hazardous Materials Control Research Institute").

2.4.1.1 No Action

Description: No action is not a category of technologies but a group of activities that can be used to address the contamination problem when no remediation measures will be implemented. These activities mentioned below will be used to construct a No Action Alternative later in this report as required by Superfund Amendments and Reauthorization Act (SARA) and the National Contingency Plan (NCP).

- o Increase public awareness through public meetings, presentations in local schools, press releases, and posting additional signs
- o Restrict access to the lake for recreational activities
- o Prohibit the utilization of lake water for irrigation purposes
- o Monitor sediment, lake water and fish and assess contaminants migration periodically

Initial Screening: The No Action approach is included through the detailed evaluation of alternatives as a baseline for comparison with other remedial alternatives.

2.4.1.2 Containment

The primary route of exposure to the sediment-bound arsenic in Union Lake is ingestion of the sediments. Isolation of the contaminated sediments from the surrounding environment would eliminate this route of exposure. The containment technologies evaluated below either provide some degree of isolation or are functionally associated. Containment of contaminated sediments would consist of capping, covering and barriers.

Capping

Capping technologies isolate the sediments by installing a cover that contains the sediments in place and, with varying levels of effectiveness, eliminates direct contact, particulate suspension and dust generation. Capping of contaminated sediments could be achieved by utilizing any one or a combination of a clay cap, synthetic membranes and chemical sealants. The cap is normally intended to be temporary, but could be permanent where extensive subsurface contamination precludes excavation and removal of wastes because of the potential hazards and/or unrealistic costs.

- Clay Cap

  Description: Clay layers are commonly used as cover for landfills that contain both hazardous and nonhazardous wastes. Bentonite, a natural clay with high swelling properties, is often transported to a site and mixed with on-site soil and water to produce a low permeability layer. An impermeable clay cap would not only physically isolate the contaminated sediments, but also prevent interaction between the sediments and the overlying water. An impermeable clay cap would also minimize the leaching of contaminants to lake water by creating an impermeable barrier.

  Initial Screening: The installation of a clay cap on the sediments under lake water would require extensive dewatering and a stable subbase, which are almost infeasible techniques. Clay caps are susceptible to cracking, settling and ponding of liquids, particularly when oversaturated with water resulting in loss of impermeability and fine material suspension. Because of low implementability and low reliability, the technology of clay capping for sediment is eliminated from further evaluation. However, clay capping is feasible and effective for landfill construction.

- o Synthetic Membranes

  Description: Flexible synthetic membranes are made of polyvinyl chloride (PVC), chlorinated polyethylene (CPE), ethylene propylene rubber, butyl rubber, Hypalon and neoprene (synthetic rubbers), or elasticized polyolefin (USEPA, 1985b). Recent applications have seen the use of synthetic materials as both liners and caps in landfills and other waste facilities. Thin sheets are available in sections of variable width and the sheets are overlapped and spliced in the field. Special adhesives and sealants are used to ensure linear integrity.

  Initial Screening: The installation of a synthetic membrane on the sediments under lake water would also require extensive dewatering and a stable subbase, and has the same infeasibility as that of a clay cap. The integrity of synthetic liners can be damaged by uneven settling. Synthetic liners under water would require an overlaying anchor layer to minimize damage and to prevent the liner from floating. Synthetic liners are labor-intensive, since sealing requires special field installation methods, particularly for submerged installation. Due to the low implementability and low reliability, this technology is eliminated from sediment capping. However, synthetic membranes will be retained for evaluation as part of a multimedia cap for landfill facilities.

- o Chemical Sealants

  Description: Chemical stabilizers and cements can be added to relatively small amounts of on-site soils to create stronger and less permeable surface sealants. Portand cement or bitumen (emulsified asphalt or tar) is suitable for mixing with sandy soils to stabilize and waterproof them. Other soil additives include chemical dispersants and swell reducers. Soluble salts such as sodium chloride, tetrasodium pyrophosphate, and sodium polyphosphate are added primarily to fine-grained soils with clay to deflocculate the soils, increase their density, reduce permeability, and facilitate compaction.

  Initial Screening: Extensive dewatering, mixing, spreading and compaction are required to achieve a low permeability cap. Strict moisture control and a stable subbase for chemical sealant formation are unlikely to be provided by silty sediments. Some of these sealant-sediment mixtures would not prevent biota from growing or burrowing through to the sediment underneath the seal. This technology is still in a developmental stage and very little information is available on the application of chemical sealants in a water environment, such as the effects on water quality and resistance to water forces. Based on the unique site conditions, difficulty in implementation and low reliability, this technology is eliminated from further consideration.

- Filter Fabric

  Description: Filter fabric is a woven material that comes in various pore sizes. It can be designed to allow water and gases formed by biological activity to escape while preventing the passage of most particulates. Therefore the use of filter fabric is considered to eliminate the redistribution of bottom sediments. It has a limited life expectancy, but is commonly used in landfill caps and has had some applications in water environments.

  Initial Screening: Some type of anchor or heavy material (e.g., sand, gravel) must be placed over the filter fabric to keep it in place on top of the sediments. In addition, filter fabric cannot prevent the growing or burrowing of biota into the contaminated sediment. For these reasons, it is removed from further consideration as an individual technology. Instead, it was combined with other complementary technologies, such as sand covering, for further evaluation.

Covering

- Coarse Sand

  Description: Covering contaminated sediments with a layer of coarse sand is an established practice to provide a positive effect in reducing public health risks from direct contact and possible ingestion of contaminants. The sand blanket would also reduce the environmental impact by minimizing bioaccumulation and erosion under normal weather conditions. The high density coarse sand would, to some extent, resist severe erosion during a storm event.

  Initial Screening: The effectiveness of contaminant covering would be proportional to the thickness of the sand layer installed. This technology is a proven and demonstrated simple technique. It may not provide a totally reliable barrier to biota growing or arsenic leaching. Placement of the sand layer may cause resuspension and redistribution of sediments. However, a coarse sand layer would provide a quick and economical means of lake restoration for recreational use. Therefore this technology is retained for further evaluation.

o Stone/Gravel

Description: A layer of crushed stone and/or gravel could be placed directly over the sediment. The water forces that have been resuspending and carrying the contaminated sediments would act on this rough surface of larger particles, which have a greater resistance to movement than the finer sediments underneath. This is a common engineering practice that is used to control erosion of materials in a water environment.

Initial Screening: Two major disadvantages of this material are that placement would cause major resuspension and redistribution of sediments, especially if placed in standing water, and that a significant portion of the material would immediately sink down into the soft sediment and be rendered ineffective. Furthermore, over a period of time, more of the stone/gravel layer may sink down into the soft sediments and more contaminated material would work up toward the surface. Placement of a layer of stone/gravel alone would still allow the transport of, and eventually contact with, some contaminated sediment. Therefore the technology is eliminated from further evaluation.

Barriers (Sediment Dispersion Control)

The following technologies provide for temporary or permanent barriers to isolate the contaminated sediments to minimize agitation and resuspension.

o Silt Curtains

Description: Silt curtains constructed from filter fabric are used to reduce the transport of contaminated sediments. Suspended from floats or staked into the bottom sediments, the curtain is extended around the work area. The performance of this technique is sensitive to surface water disturbances, which may tear or overtop the fabric. The technology is well developed for erosion control on land but has not been thoroughly tested in projects where highly contaminated sediments are suspended in water, especially in the case where the contaminant is associated with the very fine silt particles. However, the filtration effectiveness of this technology can be increased by using two curtains in parallel to provide a buffer zone between them to further control the suspended particles and turbidity.

Initial Screening: Silt curtains could be utilized to minimize resuspended particle migration during the sediment removal activities. This technology is retained for further evaluation.

- Dikes/Piers

  Description: Earth and rockfill structures can be used to cordon off the areas to be cleaned and isolate them from other contaminated areas, thus creating a safe area for public use. Piers can provide an effective barrier to direct the suspended sediment away from noncontaminated areas. An enclosed dike area can be pumped dry, providing a semidry state for excavation.

  Initial Screening: Piers/dikes cannot provide total isolation from the spread of contaminated sediment except within an enclosure pier. The construction of a diked area would have an adverse environmental impact on the lake ecosystem. This technology could provide a safe area for swimming, but would minimize other water sport uses such as boating. Since the configuration of sediment transport in the lake is unknown, its reliability would be considered low. For these reasons, dikes/piers are eliminated from further consideration as an individual technology.

- Sheet Piling

  Description: Sheet piling driven into the sediments can be used as a barrier to limit the spread of contaminants outside the work area. An enclosure constructed of interlocking sheet piles could substantially reduce the movement of contaminated water and suspended sediments to areas outside the piling. This technique could also be extended whereby the water within the enclosure is pumped out and work could proceed within a "dry" state. The use of sheet piling is a commonly applied technology.

  Initial Screening: In-situ dewatering would not be required for removal of the contaminated sediments since on-site dewatering for dredged sediments would be more cost effective. This technology is therefore eliminated from further consideration.

2.4.1.3 Treatment and Disposal

Complete or Partial Removal

As discussed in Chapter 3, the risk assessment identified sediments with an arsenic concentration greater than 120 mg/kg that underlie a water column depth of 2.5 feet or less to be a public health risk. The areas to be removed are presented in Figure 3-1. The total volume of sediment in Union Lake to be removed is approximately 130,000 cy.

- o <u>Excavation</u>

  <u>Description</u>: This category of removal technologies refers to construction equipment that is typically used on land to excavate and handle solid materials. The equipment includes backhoes, bulldozers, front-end loaders and drag lines. Large backhoes have production rates up to about 150 cubic yards per hour (cy/hr). Smaller models with low ground pressures are capable of working on soft soils.

  Bulldozers and front-end loaders have average excavation rates between 50 and 100 cy/hr and 70 and 180 cy/hr, respectively. They cannot load sediment but can merely push it into a pile. Dragliners are suitable for excavating large land areas to depths ranging from 12 to 30 feet deep with boom lengths ranging from 30 to 200 feet.

  <u>Initial Screening</u>: The types of equipment discussed above are not suitable to handle submerged sediment. A low ground pressure backhoe may be appropriate for excavation of site areas but probably only after dewatering. Both bulldozers and front-end loaders cannot be used to remove sediment, but could be used in support activities. Draglines would require the installation of an extensive network of access roads to reach all sections of the site. In addition, the use of drag buckets results in deep excavation when they are dropped from the boom. Such deep excavation is not required when only the top one foot of sediment must be removed.

  Based on the above considerations, these types of excavation equipment were removed from further consideration as a primary removal technology for the contaminated sediments. However, one or more of these types of equipment would be used for other support construction activities, hence excavation is retained for further evaluation.

- o <u>Mechanical Dredging</u>

  <u>Description</u>: Mechanical dredging refers to the use of excavation equipment such as clamshells and bucket loaders that are usually mounted on barges. The main

advantage of mechanical dredging is the removal of sediments at nearly in-situ densities by not adding any water, therefore maximizing the solids content of the sediment removed and minimizing the scale of facilities required for dredged material transport, treatment and disposal. On the other hand, because mechanical dredging removes bottom sediment through the direct application of mechanical force to dislodge the material, sediment resuspension and turbidity are often high. In addition, this method of sediment removal has a characteristically low production rate (USEPA, 1985c).

Initial Screening: Most of the barge-mounted dredges require from five to six feet of draft. The only parts of the lake that will be remediated are under 2.5 feet of water or less. These access restrictions, combined with the high resuspension of sediments associated with mechanical dredging, provide adequate reasons for eliminating the mechanical dredging category of removal technologies from further consideration.

o Hydraulic Dredging

Description: Hydraulic dredging utilizes water as the medium for transporting sediments from their in-place location to a discharge point. Slurries of 10 to 20 percent solids by weight are common in standard hydraulic dredging operations. The operations are usually barge-mounted and have high production rates. Four different types of hydraulic dredges are commercially available including suction/dustpan, cutterhead, hopper dredge and horizontal auger-cutter dredge.

The plain suction dredge relies solely on suction to dislodge, capture and transport the excavated slurry. The dustpan dredge is a modified suction dredge which features a wide flared dredging head utilizing high-pressure water jets to loosen and agitate sediment, and then capture them in the dustpan. Both types are effective in the removal of relatively free-flowing sediments.

A cutterhead suction dredge utilizes circular cutter blades which rotate at the bottom of a suction pipe. This dredge is suitable for dredging both fine (silt and clay) and coarse (gravel and loose rock) materials.

The hopper dredge is basically a self-contained ship that uses suction to draw sediments into internal hopper compartments. After all hoppers are full, the dredge is moved to a transfer location where the materials are pumped out. This dredge requires extensive maneuvering space and is used for ocean operations.

The horizontal auger-cutter dredge utilizes a hydraulically operated boom to raise and lower an auger/cutter/suction assembly to the sediments. The sediments initially loosened by the auger/cutter assembly are then transported by suction as a slurry by a floating pipeline or transfer barge to the treatment/disposal location. Smaller versions of this dredge can remove a maximum depth of sediment of approximately one and a half feet with each pass, and can be transported to relatively isolated (in terms of navigation) water bodies such as inland rivers. A series of tests on the most commonly used portable dredge, a Mud Cat, showed that resuspension of sediment was low and the resuspension plume in the surrounding water was confined to within 20 feet of the dredge (USEPA, 1985e)

Initial Screening: The suction/dustpan dredges are usually large vessels geared for maintenance dredging of major waterways. Due to their size and draft they would not be accessible to Union Lake. In addition, underwater plants and debris could block the suction lines. Therefore, the suction/dustpan dredges are considered unimplementable and are eliminated from further evaluation.

The cutterhead dredge is usually designed for large production projects and usually mounted on a large barge. Due to its size and five to six foot draft requirements, it would not be accessible to the site area and is eliminated from further evaluation.

The hopper dredge requires extensive maneuvering to operate. Under anticipated site conditions and nominal water depths, this system is not considered appropriate for Union Lake. It is therefore eliminated from further consideration.

Portable horizontal auger-cutter dredges are in wide use, particularly in shallow waters such as small reservoirs, streams and lagoons. They also characteristically have low depths of vessel draft (many less than two feet) allowing them to be used in a shallow-water application. Because of the accessibility to the site and low sediment resuspension, this type of hydraulic dredge is retained for further evaluation.

- **Pneumatic Dredging**

  Description: Pneumatic dredges use compressed air and hydrostatic pressure to draw sediments to the collection head and through the transport piping. Four types of Pneumatic dredges including Airlift, Nametech, Oozer and Pneuma are commercially available. Pneumatic dredges can yield denser slurries than conventional hydraulic dredges with lower levels of turbidity and resuspension of solids, but they are capable of only modest production rates. These dredges can be relatively easily dismantled and transported by truck, but have limited availability in the United States.

  Initial Screening: Some pneumatic dredges may not be suitable for shallow deposits because they require a minimum depth, greater than what is available in Union Lake, in order to build up enough air pressure for operation. Some of these dredges are being evaluated by the USEPA for the removal of contaminated sediments, however, operational data are limited (USEPA, 1985c). Because of the limited availability, minimum depth requirements, and lack of operational data, this category of dredges is eliminated from further evaluation.

On-Site or Off-Site Treatment Technologies

Although the same remedial technologies are applicable for on-site or off-site treatment of sediments removed from the Union Lake, on-site treatment should be considered first to minimize transportation and handling costs. Even when on-site treatment is not completely possible, steps should be taken on-site to reduce the sediment water content and volume in order to minimize transportation costs. The applicability of complete or partial on-site treatment will depend primarily on the availability of land upon which to construct facilities. It appears that sufficient land is available at the inland area of Union Lake for sediment handling and treatment. Table 2-3 presents a list of the on-site and off-site treatment technologies that were screened relative to their potential applicability and feasibility for the cleanup of contaminated sediments.

Thermal Treatment - Sediment

This technology category includes incineration units and wet oxidation units to treat the arsenic contaminated sediments.

Arsenic compounds can be vaporized in the range of 100°C to 450°C and can be oxidized to form an As_2O_3 emission. The vapor-phase arsenic emission should be treated in an air pollution control device such as a water scrubbing system.

- Incineration

Description: Incineration involves the thermal oxidation or destruction of organic matter. Incineration units such as multiple hearth, rotary kiln or infrared incineration systems would evaporate water from the sediment slurry and decompose any organic matter. Therefore they could be used for sediment drying and volume reduction. Incineration will only vaporize arsenic from the sediments into the scrubbed water. Subsequent and suitable treatment is required to remove arsenic from the scrubbed water prior to discharge to the lake. There is currently no established incineration technology that will destroy arsenic; only vaporize, sublime and melt arsenic. Either portable or stationary equipment is available for both on-site and off-site incineration. To be useful in either case, the processing capacity of the incinerator should be consistent with the rate of sediment generated by the dredging operation.

Initial Screening: The vaporization of arsenic would not require the high temperatures generated by an incinerator. Incineration requires very high capital cost, and operating and maintenance costs. In addition, the costs of scrubbed water treatment for arsenic removal are also estimated to be very high. Incineration may melt a certain amount of arsenic in ash, resulting in a problem with regard to the disposal of the potentially hazardous ash. For these reasons, incineration is considered ineffective, and is eliminated from further evaluation.

- Wet Oxidation

Description: Wet air oxidation or wet supercritical water oxidation uses elevated temperature (500°F to 600°F) and pressure (100 to 500 atm) to oxidize contaminants. This process was developed mainly for treating pumpable aqueous and sludge wastes, which are too dilute (less than 15 percent organics) to treat economically by incineration. There is currently no established wet oxidation technology that would destroy arsenic. This technology would only vaporize and oxidize arsenic.

Initial Screening: The wet oxidation products containing arsenic oxides would remain dissolved and suspended in the liquid. The off-gas would contain dissolved arsenic oxides and hydrocarbon from the organic matters in the sediments. It would be very difficult to separate the arsenic-contaminated suspended solids and the inert fine silt. This technology category has not been demonstrated feasible for arsenic removal in a pilot-scale test or a full-scale operation. Therefore wet oxidation technologies are eliminated from further evaluation.

Chemical Treatment - Sediment

Chemical treatment can be used to remove arsenic from both the dredged sediment and the associated liquid wastes. Sediments can be treated chemically using acidification/alkalization, extraction and fixation.

- Acidification/Alkalization

  Description: Acidification and alkalization consist of the addition of an acid or an alkali to the sediments to solubilize and leach arsenic into solution so that the arsenic can be removed from the sediments. Hydrochloric acid and sodium hydroxide are the most commonly used acid and alkali for this type of treatment.

  Initial Screening: The treatability tests showed that extraction of arsenic from the sediments using acidic or alkali solutions was essentially no different in extraction efficiency than water. Therefore both acidification and alkalization are eliminated from further evaluation.

- Extraction

  Description: This technology would involve the extraction of the arsenic from the dredged sediments using water, a solvent, a wetting agent or any combination of the three. The supernatant solvent (extractant) containing the arsenic would then be further treated for arsenic removal prior to discharge to the lake. The sediment after washing with water for solvent recovery would be disposed of as a non-hazardous waste.

  Initial Screening: Extraction was evaluated in the bench scale treatability studies (Section 6.0 of RI Report) to determine the feasibility of this technology to extract arsenic from the sediments. The tests involved using extracting media such as water, sodium citrate, sodium oxalate and ethylenediaminetetra-acetate (EDTA).

  The treatability test result showed that the resultant coarse sand after a water wash contained 36 mg/kg arsenic, compared with an initial sediment (sand plus fine silt) concentration of 2780 mg/kg. Based on this test and on other information gathered in the RI, it was assumed that the leachates from the coarse washed sand would contain a low enough arsenic concentration that it would be considered delistable and would be disposed in a non-hazardous landfill. The separated water and fine particles containing arsenic could then be treated on subsequent technologies to remove/fixate the arsenic. Because of its effectiveness in lowering the arsenic concentration in the washed sediments, this technology is retained for further evaluation. The delisting criteria for these sediments will be explained in detail in Chapter 3.

o <u>Fixation</u>

<u>Description</u>: Fixation is a chemical process whereby contaminated sediments are converted into a stable cement type matrix, free of water. Cement, lime, fly ash, sodium silicate, organic polymers, pozzolan, and asphalt can be used to bind or hydrate the free water available in the dredged sediments. Commercial proprietary agents are available for both organic and inorganic contaminant fixation. The contaminated sediment treated with any of these agents develops properties ranging from a loose sand or gravel to a weak concrete. The stable end product does not leach appreciable amounts of arsenic and can normally be classified as a "non-hazardous" waste if it passes the RCRA EP Toxicity Test and the EPA Multiple Extraction Procedures (MEP) Test.

<u>Initial Screening</u>: Bench-scale fixation tests were performed on sediment samples using a commercial silicated blend known as K-20/LSC (manufactured by Lopat Enterprises). Carbon powder, Portland cement and fly ash were also tested as fixation agents. The fixation formulations used were designed to produce fixated solids with leachates (produced from an EP TOX test) of less than 5 mg/l of total arsenic. The tests achieved a level of approximately 1 mg/l arsenic in the leachate, much lower than the single target. The tests were not optimized to achieve a further reduced leachate concentration, although the vendor indicated that a more optimized leachate could be achieved.

Delisting criteria for classification of solids as RCRA non-hazardous require that a leachate from an EP Toxicity test have a contaminant concentration less than that computed from the USEPA's VHS model (1986). For the sediment under consideration the leachate must be less than 0.320 mg/l arsenic. The treatability tests achieved a leachate of 0.800 mg/l arsenic using a

1:1 formulation ratio (chemicals : sediment). By modifying the formulation ratio it is believed the sediments could be fixated to produce an EP Toxicity extract with less than 320 ppb. Therefore this technology is retained for further consideration. Additional treatability tests would be needed to confirm/optimize the formulation ratio. The delisting requirements are discussed in detail in Chapter 3.

Physical Treatment - Sediment

Physical treatment processes are applicable for handling sediments from dredging operations both to thicken and dewater the sediments for subsequent treatment and disposal. Physical treatment processes are also applicable to treat the supernatant water to allow discharge to Union Lake.

Physical treatment processes evaluated for handling sediments include: hydroclones, gravity thickeners, drying beds, sedimentation basins, lagoons, dehydro drying beds, ultrasonic dewatering, centrifuges, filter presses, vacuum filters, and belt filter presses. Physical treatment processes evaluated for supernatant water treatment include: clarification, filtration, ion exchange, reverse osmosis, and adsorption.

o Hydroclones

Description: Hydroclones can be used to separate heavy (i.e. large diameter) particles from fines (i.e. small diameter particles) that are present in the sediments. The sediment is diluted with water to produce a slurry of approximately 20% solids. The slurry is pumped, under moderate pressures of 10 to 20 psig, into the hydroclone at a tangential angle. The high rotational flow in the hydroclone causes all the particles to move towards the wall because of the centrifugal force and downward to the apex because of gravitational action. Proper selection of the size and operating pressure can induce the concentration of large (i.e. sand) particles in the underflow while the fines would concentrate only slightly in the underflow (i.e. pounds fine/pound water in underflow is only slightly greater than the pounds fines/pound of water in the feed). The underflow is high in solids (i.e., 40 to 50) and has a much lower water flow than the overflow. Therefore most of the fines leave the hydroclone in the overflow stream.

Initial Screening: Hydroclones are a feasible technology for separating fines from larger particles in slurry streams. This process is therefore retained for further consideration for removing the fine from the coarse sediment from the lake.

- Drying beds

  Description: Drying beds could be utilized to gravity-drain free liquids from sediments, through a permeable layer. Sediment drying can be accomplished at a relatively low cost in a reasonable amount of time using, for example, sand beds. The drying beds consist of an upper layer of sand and a lower layer with an underdrain system. Local climate such as temperature, precipitation, sunshine and humidity will affect the drying efficiency. It is possible to obtain 45 percent solids content or more in two weeks.

  Initial Screening: Sediment dewatering using drying beds is labor-intensive and requires a significant land area. Since the feasible sediment treatment technologies for the site, such as extraction and fixation, would not require a high degree of dewatering, drying beds are considered not practical relative to other available dewatering and thickening technologies. Therefore drying beds are eliminated from further consideration.

- Gravity Thickeners

  Description: Gravity thickeners are similar to conventional circular clarifiers except that they have a greater slope and are constructed with a heavier raking and pumping mechanism. The dredged sediment slurry would enter the center of the thickener unit and solids would settle into a sump at the bottom. The solids would be removed for treatment or disposal, and the supernatant would be discharged from the overflow wier system for treatment.

  Initial Screening: Gravity thickeners are a feasible technology for thickening the sediment prior to extraction or fixation treatment as demonstrated in the bench-scale tests. This process is implementable and effective, and is therefore retained for further evaluation.

- Sedimentation Basins/Lagoons

  Description: Sedimentation basins and lagoons are two of the oldest and simplest processes for dewatering solids. Common design practice would use a two lagoon or sedimentation basin system; as one is being filled, the other is being emptied. The side slopes and bottoms of the basins would be lined to prevent leakage. Sediments would be retained in the basin while the supernatant would be decanted and pumped away for treatment. The solids would be collected for further treatment and disposal.

Initial Screening: Sedimentation basins and dewatering lagoons are not practical for sediment dewatering due to the site-specific conditions. Dredging will be performed over the perimeter of Union Lake, therefore a mobile type facility (such as a gravity thickener) is preferred. These technologies are considered unimplementable and are eliminated from further consideration.

- Dehydro Drying Beds

Description: This technology is similar to a regular drying bed except that a flocculant is added to the dredged sediment slurry and the water is then filtered through a permeable mat by means of a vacuum system. The settling of dredged sediments can be accelerated by using this process. This method requires that the contaminated sediment and associated dredge slurry be evenly distributed over the permeable mats. The water is then drawn through the bed aided by a vacuum. The supernatant is collected in a sump and removed or stored for eventual treatment. Approximately 90 percent of the water in the dredged material can be removed by this process. The dehydro drying beds are a relatively new concept utilizing conventional technical practices.

Initial Screening: Dehydro drying beds perform a high degree of dewatering and can improve drying bed dewatering efficiency. Based on the same criteria discussed for conventional drying beds, dehydro drying beds are considered not practical for this site relative to other available dewatering and thickening technologies. Therefore this modified drying bed technology is eliminated from further evaluation.

- Ultrasonic Dewatering

Description: This system uses ultrasonic vibrations to remove water from solids. This technique is a new technology that has limited documented success. Its applicability to dewatering sediments with high organic content is not known; however, it has been used in the mining and processing industry.

Initial Screening: Because of the unknown applicability to sediments with high water and organic contents, and the limited availability of the technology, this remedial technology is eliminated from further consideration.

- Centrifuge

  Description: A centrifuge is typically composed of a spinning drum that creates high outward forces that push solids to a screen on the perimeter of the cylinder. Solids are retained on the screen while water is discharged from centrally located weirs. Centrifuges are normally operated on a continuous basis for sludge dewatering.

  Initial Screening: Centrifuges may not be applicable to sediments due to the presence of some abrasive solids such as sand and gravel, which can cause wear and tear of the centrifuge, increased maintenance and frequent replacement of parts. Centrifuges, therefore, are eliminated from further evaluation.

- Filter Press (Plate and Frame)

  Description: Filter presses may be used to dewater sediments by forcing sediments under pressure into a series of plates and chambers fitted with a fine filter cloth. Water is forced through the filter cloth into a collection system, and the plates are then separated and the solids removed for treatment and/or disposal. The system is operated on a batch basis.

  Initial Screening: This dewatering technology is labor-intensive and not practical for dewatering sediments at the site due to relatively high operation and maintenance costs, as well as a very limited capacity. This technology is not retained for further evaluation.

- Vacuum Filter

  Description: Vacuum filters are commonly used to dewater sludges from wastewater treatment systems. Vacuum filters utilize a rotating cylinder with an internal vacuum to draw water through the filter medium while leaving solids as a layer on the filter cloth. The dewatered solids are continuously scraped off the rotating filter medium to a conveyor system.

  Initial Screening: Vacuum filtering is a feasible technology for dewatering sludges generated from the supernatant or extractant treatment system. This technology is therefore retained for further evaluation.

o **Belt Filter Press**

Description: The belt filter press uses two vertically or horizontally moving belts to squeeze water from the solids. Belt filters have been commonly used for the sludge dewatering which requires preconditioning such as the addition of a coagulant and/or a polymer. Sludges containing fine particles would require preconditioning to improve the dewatering efficiency.

Initial Screening: Belt filters presses accomplish the same goal as vacuum filter, however, belt filter presses are more efficient for nonfiber or high-viscosity sludge. Therefore this technology is eliminated from further consideration.

In-Situ Treatment Technologies

The contaminated sediments to be remediated are located in shallow water areas in Union Lake (less than 2.5 feet deep). The implementation of in-situ fixation and treatment technologies for the sediments would require intensive isolation and dewatering of the sediments and would result in higher cost and longer construction period. The long-term stability of the treated sediments would be reduced significantly under the dynamic water environment. The following chemical and physical in-situ treatment technologies outlined in Table 2-3 were screened relative to their potential applicability and feasibility to the cleanup of contaminated sediments.

In-Situ Chemical Treatment

The in-situ chemical treatment technologies considered involve the introduction of an agent that either removes the arsenic from the sediments or binds it to the sediments in such a way that the arsenic is no longer available or capable of being leached and resuspended.

o **Extraction**

Description: The sediment is washed with some appropriate acid, alkali, or other solvent to dissolve or solubilize the arsenic. The area to be treated must be isolated by a cofferdam and dewatered with pumps. This enclosure is then flooded with a solvent using hydraulic sprayers. The sediment and solvent are then mixed using adequate agitators such as plows, harrows and rotary tillers. The elutriate (solvent containing the arsenic) is then collected from the isolated area and is pumped to a treatment system. The contaminated solvent is then pumped to a treatment system.

Initial Screening: Most of the sediments in Union Lake are composed of organic silts. The in-situ water extraction would resuspend the fine particles and would result in pumping a large quantity of sediment with the elutriate to the treatment system. The treatability studies showed that these fines were not easily removed from the extractant solution. This site-specific condition would make in-situ extraction no more attractive than on-site extraction. It would be very difficult to implement this technology. Thus construction costs would be higher and construction duration would be longer. Therefore in-situ extraction is not considered a practical technology for the site and is eliminated from further evaluation.

- Grout Injection

Description: The contaminated sediments are solidified by injecting a mixture of Portland cement, fly ash, activated carbon and proprietary chemicals, which traps the sediments into an insoluble matrix. The mixture can either be injected into closely spaced holes in the sediment to create vertical columns of solidified material or injected into the top layer of the sediment while simultaneously being mixed in with rotary tillers to form a whipped layer of solidified material. The area to be treated would be isolated by a cofferdam and dewatered with pumps, thus the moisture of sediments could be controlled in an effective range. In general, the in-situ fixation is more difficult than the on-site removal/fixation, particularly for the sediments under water.

Initial Screening: Due to the difficulty in obtaining moisture control for the in-situ sediment fixation, it is difficult to assess how effectively the grout will penetrate the sediment and how long the grout will remain intact. Also, because of the high organic content of the sediment and the dynamic water environment, the long-term stability of grout injected sediment is unknown. Due to the uncertainties and technical problems with this technology, it is removed from further evaluation.

In-Situ Physical Treatment

There was only one physical in-situ treatment technology selected for initial screening.

- Vitrification

  Description: In-situ vitrification (ISV) is a thermal treatment process utilized to stabilize chemically contaminated soils in place. ISV destroys organic contaminants by pyrolysis and incorporates inorganic contaminants into a glass-like material that essentially renders these contaminants immobile. ISV involves placing electrodes and a graphite/glass mixture in a cross pattern in the sediment, then heating the sediment to molten temperatures by applying a voltage to the electrodes. As the surrounding sediment melts, it becomes electrically conductive. The resulting vitrified solid mass should be very leach-resistant and durable. This process is quite costly and thus has been restricted to the treatment of radioactive or very highly toxic wastes.

  Initial Screening: In-situ vitrification is still an emerging technology, but it is known that if the materials to be treated have a high water content, the effectiveness is reduced and the costs significantly increase. It is unlikely that ISV can be used to treat sediments under water. The technology is considered unimplementable and unreliable and is thus eliminated from further consideration.

2.4.1.4 On-site or Off-site Disposal Technologies

If one or more of the removal technologies in Section 2.4.1.3 are incorporated into potential alternatives, then the corresponding disposal of the removed sediments must also be addressed. The requirements for disposal can be divided into two categories, depending on whether the sediments are still hazardous or have been treated so as to be delistable as non-hazardous wastes. There are also two general locations for disposal, namely on-site or off-site. The following technologies listed in Table 2-2 represent various combinations of these waste classifications and possible disposal options.

Hazardous Waste Disposal

Under this category, three different locations are discussed for the ultimate deposition of the contaminated sediments whose arsenic concentrations qualify them as a hazardous wastes.

- Construct On-Site RCRA Landfill

  Description: A new RCRA Subtitle C containment facility could be constructed somewhere within the site boundaries to receive the treated sediments that are not delistable. Although permitting requirements under the laws are not required for fund-financed actions under CERCLA (USEPA, 1985c), the landfill would have to be designed with a double liner system; two leachate detection, collection, and removal systems; and a groundwater monitoring system, according to applicable RCRA requirements (USEPA, 1985b).

According to an interpretation of the "site boundaries" given to EPA Region II by EPA Site Policy and Guidance Branch personnel, the "site" consists of the ViChem Plant property and possibly areas immediately adjacent to the plant. While Union Lake itself is considered part of the ViChem Superfund site, a landfill adjacent to Union Lake would not be considered "on-site" since lands adjacent to the lake are not within the "area of contamination". Therefore an "on-site" landfill would consist of a landfill constructed at the ViChem Plant site itself, approximately 10 river miles upstream from Union Lake.

<u>Initial Screening</u>: Although landfilling hazardous waste was and still is widely used as a management practice, it is now being discouraged by the USEPA, which makes obtaining approval for construction of a new facility very difficult. The disposal facility would be designed to satisfy all the applicable regulations. The Vineland Chemical Plant site is a viable location for on-site RCRA disposal. Although acquisition of site properties may be difficult, this technology is retained for further consideration.

- <u>Construct Off-Site RCRA Landfill</u>

  <u>Description</u>: The construction of a RCRA Subtitle C facility could be undertaken at some location in Salem, Cumberland or Putnam Counties. A site in one of these counties would minimize hauling distances while still allowing an adequate siting area in which to define the optimum location of the facility. However, since it would not be located within the CERLCA site, federal and state permits would have to be obtained.

  <u>Initial Screening</u>: The permitting process requires extensive investigations and acceptance by numerous agencies. Important factors affecting the regulatory acceptance would be the definition of site conditions, design, construction, operation, public concerns, closure, and post-closure monitoring. The land-base disposal restriction regulations prohibit off-site landfilling without treatment after November 1988, thus this technology may not be feasible without treating the sediment. Because of the difficult administrative efforts, this technology is eliminated from further evaluation.

- o <u>Existing Off-Site RCRA Landfill</u>

  <u>Description</u>: The waste material could be hauled to an existing RCRA Subtitle C landfill facility that is already permitted to accept treated material that is not delistable. This provides a straightforward solution to the disposal problem, but unit costs are high due to transport distance and disposal fee structure. In addition, volume limitations at a facility may put a limit on the quantity of waste that can be disposed of in this fashion.

  <u>Initial Screening</u>: Off-site disposal in an existing RCRA facility would have minimal long-term public health and environmental impacts. The land-based disposal restriction regulations prohibit off-site landfilling without treatment after November 1988, thus this technology is not feasible without treatment of the sediment. This technology is, therefore, retained for consideration in combination with treatment on-site or off-site.

<u>Nonhazardous Waste Disposal</u>

If the arsenic-contaminated sediment can be treated by one of the technologies evaluated in Section 2.4.1.3 in order to be delistable and/or classified as nonhazardous, then its disposal would no longer be limited to just a RCRA Subtitle C Facility. Methods for the disposal of nonhazardous sediments are discussed in this category.

- o <u>Construct On-site Nonhazardous Landfill</u>

  <u>Description</u>: As discussed in the previous category, a location within the boundaries of the ViChem Plant site may comply with the exclusionary criteria. Because this landfill would only be accepting what is considered to be nonhazardous waste, the design and operation requirements would be similar to that of a municipal sanitary landfill.

  <u>Initial Screening</u>: Construction of a sanitary landfill with associated reduction in hazardous properties of the toxic wastes may be acceptable to regulatory agencies and the community if the treated material if delistable. Data from the Union Lake RI suggests that the treated (fixated or water wash extracted) material may be delistable. This option is retained for further evaluation as a potential disposal alternative.

- Existing Off-Site Nonhazardous Landfill

  Description: An existing licensed landfill could be used for the disposal of nontoxic wastes. There would only be disposal costs associated with this technology, and no costs to the remediation associated with the design, operation and maintenance, closure, or monitoring of a new facility. It is assumed that there would be no problems with using an existing landfill facility.

  Initial Screening: Treated materials may be disposed in nonhazardous landfills and even used as cover material if the material is delisted. Preliminary investigations into the availability of a local landfill willing to accept the treated sediments are encouraging; therefore, this technology is retained for further consideration.

- Construct Off-site Nonhazardous Landfill

  Description: Somewhere within Salem, Cumberland or Putnam Counties, a new landfill could be sited, designed, constructed, and operated to receive the treated sediments. After being filled, it would be closed and monitored. Since the waste is not hazardous, requirements for the landfill would be less stringent. However, because it would not be located within the CERCLA site, federal and state permits would have to be obtained.

  Initial Screening: Again, because of the permitting, the siting studies, and the public's reluctance to have a landfill sited nearby, this technology is not retained for additional evaluation.

- Ocean Disposal

  Description: The disposal of nontoxic sediments in the Atlantic Ocean can be considered. Barges would haul the material to an acceptable disposal location in the Atlantic Ocean and then deposit the sediments. Permits and the assessment of environmental impacts are important considerations for this technology.

  Initial Screening: The current regulations in 40 CFR 220-227 require a long and involved testing process in order to acquire a permit to dispose of the sediments in the Ocean. Ocean dumping would require ocean-going barges and barge loading facilities to be constructed at or near the site. This would be impractical for Union Lake. Therefore ocean disposal is eliminated from further consideration.

- Deep Lake Deposition

  Description: Deep lake deposition of the treated sediments is a cost-effective disposal alternative. Barges would haul the material to deep portions of Union Lake and deposit the treated sediment.

  Initial Screening: This disposal activity would trigger RCRA requirements including the land ban. Therefore any material to be deposited in the lake would require delisting. Data from the Union Lake RI suggests that the treated material may be delistable. Therefore this technology is retained for further evaluation.

Chemical Treatment - Water

The supernatant water associated with the sediments that would be removed by dredging would require arsenic, iron and suspended solids removal before discharge back into Union Lake. In addition, the extractant generated from the water extraction process also required the removal of arsenic and suspended solids. Suspended solids removal would also achieve removal of portions of the arsenic and iron that are associated with the suspended solids. Further removal of arsenic, iron and suspended solids can be achieved by chemical coagulation/flocculation/precipitation. Other technologies screened include biodegradation, oxidation, clarification, filtration, ion exchange, adsorption, reverse osmosis and neutralization.

- Coagulation/Flocculation/Precipitation

  Description: Chemical coagulation/flocculation/precipitation consists of the addition of chemicals such as ferric chloride, lime, sulfide and polymers to precipitate arsenic, iron and suspended solids from solution. Flocculation is the gentle agitation of the coagulated solids to promote the growth of floc particles to increase precipitation rates and removal.

  Initial Screening: This process is used primarily in conventional wastewater treatment systems to remove arsenic, iron and suspended solids. Ferric chloride precipitation is the key unit operation for arsenic removal at the existing ViChem wastewater treatment plant. Therefore chemical coagulation/flocculation/precipitation is retained for further evaluation.

- Biodegradation

  Description: Biodegradation utilizes bacteria or other microbes to biologically oxidize or reduce contaminants by converting the organics to carbon dioxide, water, methane and new cellular biomass. Proper control of the treatment environment (pH, nutrients, temperature, and oxygen) is critical to the reproduction and growth of the microbes. However, bacteria and microbes that are used for one contaminant may be inhibited by the presence of another contaminant.

Initial Screening: The bench-scale treatability tests for the arsenic alkalization extraction from the sediments indicated that the extractant contained a large amount (4%) of very fine suspensions, high in organic content. It is believed that these fine particles can be settled out of solution by a combination of coagulation/flocculation/precipitation. Therefore there is no reason to biologically treat the water extractant solution containing the fines, this technology is eliminated from further consideration.

- Oxidation

Description: Chemical oxidation is utilized to change the chemical form of a hazardous material in order to render it less toxic, or to change its solubility, stability, separability or otherwise change it for handling or disposal purposes. The oxidation agents would include hydrogen peroxide, potassium permanganate, ozone, sodium hypochlorite and calcium hydrochlorite.

Oxidation processes can be used to treat diluted wastewater containing oxidizable organics and can also be used as an effective process for pretreating wastes prior to biological treatment.

Initial Screening: The ViChem wastewater treatment plant has utilized potassium permanganate oxidation to oxidize organic arsenic (mainly monomethyl arsenic acid and dimethyl arsenic acid) to arsenate. Arsenate is the form of arsenic that is most readily removed by chemical coagulation, flocculation and precipitation. Chemical oxidation is effective and implementable, and is therefore, retained for further evaluation.

Physical Treatment - Water

Physical treatment processes that were screened for treating the liquid wastes generated from dewatering or water extraction from the dredged sediments include clarification, filtration, ion exchange, reverse osmosis and adsorption.

- **Clarification**

  Description: The primary function of clarification is to remove settleable suspended solids to produce a clear waste stream. The clarifier is equipped with a solids removal device to facilitate clarification on a continuous process basis resulting in a lower solids content for the effluent. Clarifiers are mostly in a circular form and their performance is based on the settling characteristics of the sediment and the design criteria of the units.

  Initial Screening: Clarification, which is a sedimentation process, has been shown in the bench-scale studies to be applicable for removing suspended solids in the dredged supernatant. This technology, therefore, is retained for further evaluation.

- **Filtration**

  Description: Filtration is used to remove organics and solids that are not settleable. The use of different media is possible, the most common being sand filtration or mixed media filters, which include sand and anthracite. Sand filtration is typically used after clarification to remove nonsettleable solids. A mixed-media filtration system consists of a layer of anthracite and a layer of sand to effect the filtration and adsorption of fine particles. This type of filter media would selectively remove the insoluble particles that are present in the suspended solids of the supernatant.

  Initial Screening: Filtration is applicable to the removal of non-settleable suspended solids and is retained for further evaluation.

- **Ion Exchange**

  Description: Ion exchange is a process whereby the toxic ions are removed from the aqueous phase by electrostatic exchange with relatively harmless ions that are held by ion exchange resins. Ion-exchange is used to remove metallic cations and anions, inorganic anions, organic acids and organic amines. Fixed bed countercurrent systems are the most widely used ion exchange systems. The continuous countercurrent systems are suitable for high flows. The strong base anion exchange resins are the most effective resins for arsenic removal.

Initial Screening: Bench-scale tests indicated that the strong base anion exchange resins in chloride form (Amberlite IRA-400 and Dowex AG-I-X8) removed arsenic from groundwater to below the discharge limit level of 0.05 mg/l. The ion exchange process would be feasible for use as a polishing unit for further arsenic removal following the physical-chemical precipitation process; however, need for a polishing process unit is not anticipated due to the high solids and subsequent arsenic removal provided by clarification. Thus ion exchange is eliminated from further consideration.

o Adsorption

Description: The process of adsorption involves contacting a waste stream with an adsorbent, usually by flow through a series of packed bed reactors. Adsorption efficiency depends on the strength of the molecular attraction between the adsorbent and the adsorbate, molecular weight, type and characteristics of adsorbent, electrokinetic charge, pH and surface area. Activated carbon has been demonstrated to be an ineffective adsorbent for arsenic removal from aqueous wastes (Lee, 1982), whereas activated alumina has been shown to be an effective adsorbent for arsenic contaminated wastewater.

Initial Screening: The bench-scale treatability studies indicated that activated alumina adsorption displayed a much better arsenic removal efficiency than activated carbon adsorption. Activated alumina adsorption could be used as a polishing process for further arsenic removal following the physical-chemical treatment for the water extractant solution but, as discussed under ion exchange, the need for a polishing unit is not anticipated. Therefore adsorption is eliminated from further consideration.

o Reverse Osmosis

Description: Reverse osmosis is the application of sufficient pressure to the concentrated solution to overcome the osmotic pressure and force the net flow of water through the membrane toward a dilute phase. This allows the concentration of solute (impurities) to be built up in a circulating system on one side of the membrane while relatively pure water is transported through the membrane. Ions and small molecular compounds in true solution can be separated from water by this technique. The basic components of a reverse osmosis unit are the membrane, a membrane support structure, a containing vessel and a high pressure pump. The semipermeable membrane can be flat or tubular, but regardless of its shape it can act like a filter due to the pressure-driving force.

Initial Screening: The bench-scale treatability studies indicated that reverse osmosis could be used to remove arsenic from the contaminated supernatant and to produce an effluent with total arsenic concentration below 0.05 mg/l. However, this process generated an extremely high volume of reject stream and required a very high operating pressure. In addition, the membrane must be compatible with the waste stream's chemical and physical characteristics. Suspended solids and some organics will clog the membrane material, and low-solubility salts may precipitate onto the membrane surface. Therefore, reverse osmosis is not a practical and economical technology for the liquid extractant treatment and is eliminated from further consideration.

- Neutralization/pH Adjustment

  Description: Neutralization is a process used to adjust the pH (acidity or alkalinity) of a waste stream to an acceptable level for discharge, usually between 6.0 to 9.0 pH units. Neutralization may also be used as a pre- or post-treatment step with other treatment processes i.e., chemical precipitation. Adjustment of pH is done by adding acidic reagents to alkaline streams and vice versa.

- Initial Screening: Neutralization is a conventional and widely demonstrated means of adjusting the pH of a waste before and/or after chemical oxidation and precipitation. For this reason, neutralization is retained for further evaluation, if required as part of a chemical treatment system.

Off-Site Wastewater Treatment

- POTW and Industrial Waste Treatment Plant

  Description: Under this technology, the sediment supernatant or chemical extractant would be piped to a publicly owned treatment works (POTW) or industrial facility for treatment and discharge. At present, a hookup to the local POTW or an industrial treatment plant does not exist. A new piping system would have to be constructed to transport the wastewater to the area sewer system or directly to the industrial treatment plant.

Initial Screening: The City of Vineland Sewage Treatment System near Union Lake does not have the extra capacity and adequate treatment processes to handle the large volume of arsenic contaminated wastewater. Therefore the off-site POTW technology is infeasible and is eliminated from further evaluation.

The only nearby industrial waste treatment plant is the ViChem wastewater treatment plant. This plant would not have the extra capacity to handle the supernatant or extractant flow. In addition, the existing ViChem wastewater treatment plant cannot produce an effluent with arsenic below the discharge limit of 0.05 mg/l. Therefore this technology is eliminated from further consideration.

2.4.1.5 Transportation Technologies

In association with the optional off-site disposal technologies screened in Section 2.4.1.4, complementary modes of transportation must also be considered. The following methods of transportation were selected for this screening process.

- Truck

  Description: There is limited road access to the site. Trucks will probably be used to bring in equipment and materials for remediation. In addition, water-tight trucks or tanker trailers could be used to haul and transport sediment and treatment sludge. Trucks will be properly decontaminated, weighted, and manifested before leaving the site. Stringent regulations and special permits for hauling hazardous materials, and oversized and heavy loads over public highways will have to be taken into consideration.

  Initial Screening: This is the most acceptable mode of transportation. The operation is flexible, since the number of trucks being utilized can be increased or decreased depending upon the requirements. The mode of transportation does not require special loading facilities at the project site or unloading facilities at the disposal site. Trucks are therefore retained for further evaluation.

- Pipeline

  Description: A pipeline system consisting of pipes or tubing could be used to convey materials. It can be used to handle both liquids and solids; however, the solids must be in a slurry form with a water content of at least 40-60 percent. Hydraulic dredging technologies produce such a slurry, requiring a pipeline to carry the sediments to a dewatering device. A pipeline can be a very costly system, especially if booster pump stations are required to overcome steep changes in elevations and pumping distances of over one mile.

Initial Screening: A pipeline to the disposal site only for the duration of the construction period for a length of 50 to 100 miles will be extremely expensive. In addition, routing of this pipeline through various towns and along the roads will require numerous permits. This technology is eliminated for the disposal option. However, pipelines that are an integral part of a remediation process for conveying dredged/treated material from one unit to another unit will be considered.

2.4.2 Selection of Representative Technologies

Table 2-3 presents the results of the evaluation of various technologies performed in this section and the selection of representative technologies. This table identifies those technologies that are not feasible and were eliminated from further evaluation. The table also identifies the technologies that will be further evaluated in Section 3.0.

TABLE 2-3

SUMMARY TABLE OF REMEDIAL TECHNOLOGIES

Technology	Feasible - Further Evaluation Required	Eliminated from Further Evaluation
1. No Action	X	
2. Containment		
A. Capping		
o Clay Cap		X
o Synthetic Membrane		X
o Chemical Sealants		X
B. Covering		
o Sand	X	
o Stone/Gravel		X
o Filter Fabric	X[a]	
C. Barriers		
o Silt Curtains	X	
o Dikes/Pier		X
o Sheet Piling		X

---

a To be considered in combination with other technologies.

TABLE 2-3

SUMMARY TABLE OF REMEDIAL TECHNOLOGIES (cont'd)

Technology	Feasible - Further Evaluation Required	Eliminated from Further Evaluation
3. Removal		
A. Excavation		
o Backhoe	X[a]	
o Bulldozer		X
o Front-End Loader		X
o Dragline		X
B. Mechanical Dredging		X
C. Hydraulic Dredging		
o Suction/Dustpan		X
o Cutterhead		X
o Hopper Dredge		X
o Horizontal Auger-Cutter	X	
o Pneumatic Dredging		X
4. On-Site or Off-Site Treatment - Sediment		
A. Thermal		
o Incineration		X
o Wet Oxidation		X
B. Chemical Treatment		
o Acidification/Alkalization		X
o Extraction/Recovery	X	
o Fixation/Solidification	X	

TABLE 2-3

SUMMARY TABLE OF REMEDIAL TECHNOLOGIES (cont'd)

Technology	Feasible - Further Evaluation Required	Eliminated from Further Evaluation
B. Chemical Treatment (cont'd)		
o Coagulation/ Flocculation/ Precipitation	X	
o Biodegradation		X
o Oxidation	X	
C. Physical Treatment		
o Hydroclones	X	
o Drying Beds		X
o Gravity Thickeners	X	
o Sedimentation Basins/Tanks		X
o Dehydro Drying Beds		X
o Ultrasonic Dewatering		X
o Centrifuge		X
o Filter Press (Plate and Frame)		X
o Vacuum Filter	X	
o Belt Filter Press		X
o Clarification	X	
o Filtration	X	
o Ion Exchange		X
o Adsorption		X
o Reverse Osmosis		X
D. POTW and Industrial Treatment Facility		X

TABLE 2-3

SUMMARY TABLE OF REMEDIAL TECHNOLOGIES (cont'd)

Technology	Feasible - Further Evaluation Required	Eliminated from Further Evaluation
5. In-Situ Treatment		
A. Chemical		
o Extraction		X
o Grout Injection		X
B. Physical		
o Vitrification		X
6. Disposal		
A. Disposal as Hazardous Waste		
o Construct On-site RCRA Landfill	X	
o Construct Off-Site RCRA Landfill		X
o Use Existing RCRA Landfill	X	
B. Disposed as Non-Hazardous Waste		
o Construct On-Site Landfill	X	
o Construct Off-Site Landfill		X
o Use Existing Sanitary Landfill	X	
o Ocean Disposal		X
o Deep Lake Disposal	X	
7. Transportation		
A. Truck	X	
B. Pipeline	X[a]	

3.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

In this section, the technically feasible remedial technologies identified in Section 2.0 are grouped into potential remedial action alternatives. These alternatives are screened based on effectiveness, implementability and cost considerations. The purpose of the screening step is to identify alternatives that have sufficient merit to undergo detailed evaluation. This is achieved by eliminating remedial alternatives that have significant adverse environmental or public health impacts. Costs may be used to discriminate between treatment alternatives in the screening process, but not between treatment and non-treatment alternatives.

The purpose of the initial screening is to narrow the number of potential remedial alternatives for detailed analysis while preserving a range of options. The discussions and evaluations comprising this screening are not intended as a substitute for or a supplement to the detailed analysis of the alternatives conducted in the next section of this report.

3.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

A remedial action objective has been established for the remedial program for Union Lake. This objective was presented in Section 2.2.

In order to achieve the established remedial action objective, response criteria are first established to evaluate the acceptability of environmental and public health impacts and the anticipated performance of the alternative. This step establishes ARARs and other appropriate criteria in order to define performance requirements and potential human risks associated with the remedial action. Next, potentially applicable technologies identified in Section 2.0 are used to develop comprehensive medium-specific remedial alternatives on the basis of operation and performance compatibility, and the use of acceptable engineering practices. Finally, the alternatives are evaluated, in a general sense, with respect to effectiveness, implementability and cost criteria. Each step of the process is described in the following sections.

3.1.1 Development of Remedial Response Criteria

This subsection describes the use of ARARs in FS evaluations and identifies the ARARs used to evaluate the Union Lake remedial alternatives.

3.1.1.1 Use of ARARs in Remedial Alternative Evaluation

CERCLA did not provide specific guidance on standards that should be utilized to manage uncontrolled hazardous waste sites. EPA subsequently developed the ARAR concept to govern the Superfund program's compliance with other environmental and public health statutes.

Before enactment of SARA, EPA's ARAR guidance was contained in the NCP and the "Memorandum on CERCLA Compliance with Other Environmental Laws" (the Compliance Policy), which was published as an appendix to the NCP. Section 121 of SARA incorporated the ARAR concept but made several changes. Most importantly, Section 121 designated State requirements as ARARs whenever they are promulgated and identified in a timely manner, and are as strict or stricter than equivalent Federal ARARs. SARA also required the attainment of Water Quality Criteria or Maximum Contaminant Levels (MCLs) if they are "relevant and appropriate". On August 27, 1987, EPA issued an Interim Guidance document addressing the new ARAR provisions (52 Fed. Reg. 32496).

The role of ARARs in the FS process involves evaluating a remedial alternative to characterize the performance level that it is capable of achieving. Each remedial alternative must be assessed to evaluate whether it attains or exceeds federal and state ARARs.

Two types of ARARs exist: "applicable" and "relevant and appropriate" requirements of Federal and State laws. An applicable requirement is any standard or limitation that is legally binding on a CERCLA site based on the contaminant, remedial action, or location of the site. In other words, applicable requirements are requirements that would apply to response actions even if actions were not taken pursuant to CERCLA. A "relevant and appropriate" requirement is any standard or limitation that, while not applicable to the hazardous substance, action, or location of a CERCLA site, does address problems or situations sufficiently similar to those encountered at the CERCLA site for which its use is suited. When establishing performance goals for remedial alternative selection, relevant and appropriate requirements are given equal weight and consideration as applicable requirements.

If no ARAR exists for a CERCLA site, other Federal and State criteria, advisories, guidance, or proposed rules may be considered for developing remedial alternative performance goals. These "To Be Considered" materials (TBCs) are not legally binding, but may provide useful information or recommended procedures that explain or amplify the content of

ARARs. If no ARAR addresses a particular situation, or if existing ARARs do not ensure protection of human health and the environment at a particular site, "To Be Considered" material should be evaluated for use.

Each type of ARAR can be characterized further as (1) contaminant-specific; (2) action-specific; and (3) location-specific. A contaminant-specific ARAR sets health and risk-based concentration limits in various environmental media for a specific hazardous substance or contaminant. An action-specific ARAR sets performance, design, or other similar action-specific controls on particular remedial activities. A location-specific ARAR sets restrictions for conducting activities in particular locations, such as wetlands, flood plains, national historic districts, and others.

3.1.1.2 Identification of ARARs for Union Lake

This section presents a listing and general discussion of the Federal and New Jersey ARARs and "To Be Considered" (TBCs) material utilized in this Feasibility Study.

3.1.1.2.1 Listing of ARARs and TBCs

This listing is organized into the categories described above.

- <u>Contaminant-Specific</u>
  - Federal and New Jersey Drinking Water Maximum Contaminant Levels (MCLs)
  - Federal Clean Water Act Water Quality Criteria
  - New Jersey Surface Water Quality Standards
- <u>Location-Specific</u>
  - U.S. Fish and Wildlife Coordination Act
  - National Endangered Species Act
  - Federal Flood Plain and Wetlands Executive Order
  - Federal Flood Plains and Wetlands Policy
  - New Jersey Coastal Area Facility Review Act (CAFRA) Permit Requirements
  - New Jersey Wetlands (Coastal and Fresh Water) Permit Requirements

    - River and Harbor Act Section 10/Clean Water Act Section 404 Standards
    - New Jersey Soil Erosion and Sediment Control Requirements

- <u>Action-Specific</u>

    - Federal and New Jersey Hazardous Waste (Resource Conservation and Recovery Act) Treatment/Storage/ Disposal Facility Requirements
    - Federal Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR)
    - Federal and New Jersey Nonhazardous Waste Landfill Facility Criteria
    - Clean Water Act NJDPES Discharge to Surface Water Requirements
    - Occupational Safety and Health Act Requirements for Hazardous Responses
    - RCRA Characteristic Testing for Hazardous Waste Identification
    - Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste
    - New Jersey Toxic Substance Air Pollution Standards
    - New Jersey Ambient Air Quality Standards

3.1.1.2.2 General Discussions of Key ARARs and TBCs

This subsection presents general discussions of ARARs and TBCs that are the key requirements in remedial alternative evaluation and comparison. The focus of these discussions is on distinguishing between alternatives based upon ARAR/TBC attainment, rather than providing an exhaustive description of the ARARs/TBCs themselves.

- <u>New Jersey Surface Quality Standards and NJPDES Discharge Requirements</u>

New Jersey surface water quality standards furnish ambient levels that provide for the protection of freshwater systems that may be used for recreational, domestic, potable, and/or agricultural uses (after treatment). The NJDPES effluent limits are set to prevent exceedance of standards following discharge in and mixing with surface waters. To ensure that surface water discharges at Union Lake do not exceed ambient levels, the surface water quality standards are used as a conservative approach. These standards establish the design and operation goals for water treatment systems.

o <u>RCRA Regulations</u>

Sediments contaminated with arsenic are considered to be a "RCRA Characteristic" hazardous waste (40 CFR 261.24, EPA Hazardous Waste #D004) if the arsenic concentration levels in an extract produced by the EP Toxicity Test from a representative sediment sample exceed the EP Toxicity Test threshold level of 5.0 mg/l. In addition, sediments containing by-product salts from the production of MSMA pesticides (nonspecified source RCRA listed waste #K031) are also considered hazardous based on the presence of this listed waste.

Throughout this FS Report, Union Lake sediments are considered to be a RCRA listed hazardous waste based on ViChem's past and current production, and past on-site storage, of MSMA and other pesticides that involve the generation of the by-product salt waste #K031. MSMA by-product salt is deemed to be the source of the arsenic site contamination detected in sampling to date. This guidance was received by EPA Region II from EPA Headquarters Site Policy and Guidance Branch personnel. Therefore the arsenic-contaminated Union Lake sediments are considered a RCRA listed hazardous waste throughout this report.

o <u>Federal RCRA Land Disposal Restrictions (LDRs)</u>

RCRA LDRs were enacted to severly restrict the disposal of hazardous wastes in landfill, surface impoundments, injection wells and other forms of land disposal facilties. The LDRs establish Best Demonstrated Available Technology (BDAT) treatment standards for wastes prior to land disposal. RCRA characteristic wastes and RCRA listed hazardous wastes are subject to RCRA LDRs.

The RCRA characteristic wastes are part of the so-called "Third Third" of RCRA wastes, which will be subject to LDR requirements after May 8, 1990. Proposed LDR standards for these wastes are not yet developed. The RCRA listed waste #K031 (by-product salts from the production of pesticide MSMA) is part of the "First Thirds" of RCRA waste that is subject to the LDR "soft hammer" requirements as of August 1, 1988. The soft hammer certification allows #K031 wastes for which no treatment standard has been set to be placed in a landfill that meets minimum technology requirements (MTR) only until May 8, 1990 under two conditions: (1) the generator demonstrates and certifies to the EPA that either no treatment technology is practically available, or (2) that the waste has been treated to meaningfully reduce the long-term hazard of the waste when it is placed in the landfill. Soft hammer certifications, therefore, become a mini rule-making process where the generator sets the BDAT Standard (Hill, 1988). If EPA has not established a BDAT standard by May 8, 1990, land disposal of the waste is prohibited.

Based on conversations with RCRA Site Policy and Guidance Branch (SPGB) personnel, the Union Lake sediments have been confirmed to be a RCRA hazardous waste based on the presence of the listed waste #K031. According to RCRA SPGB, this waste can be declared nonhazardous through a delisting petition procedure. Delisting involves proving that the material does not exhibit the characteristic for which it was initially listed. Requirements for delisting include the nature of waste, the concentration of the contaminant in the waste, the potential for contaminant migration, the quantity of the waste disposed, and other waste mixed in. The substantive tool for delisting is the VHS model, which simulates contaminant transport through an aquifer.

Parameters of the VHS model include contaminant concentration in the leachate, penetration depth of leachate into the aquifer, distance from the disposal site to the compliance point, length of the disposal site, lateral transverse dispersivity and vertical dispersivity. With the exception of the contaminant concentration in the leachate, determined by the EP Toxicity Test, and the length of the disposal site, dictated by the volume of waste, all of the values for the model's parameters are fixed by the EPA. These values are derived from a worst case scenario.

In order to be delistable, the EP Toxicity extract for total arsenic must be less than that computed from the VHS model. For the Union Lake sediments, the EP Toxicity extract must be less than 0.32 mg/l. Based on treatability studies, other information gathered during the RI and other information from vendors, and with EPA Region II concurrence, it is assumed that the treated material (fixated or extracted) will achieve an EP Toxicity extract concentration that will satisfy the VHS model, as discussed below.

The EP Toxicity Tests conducted in the fixation treatability studies achieved an arsenic concentration in the extract of approximately 1 mg/l. At the time the tests were performed, the target delisting criterion was believed to be an EP Toxicity extract arsenic concentration of 5 mg/l, which the original treatability tests clearly achieved. Different formulations to optimize additive addition rates were not tried, nor were additional mixtures tried to determine the lowest arsenic concentration that could be achieved in the EP Toxicity extract, since the target concentration (less than 5 mg/l) was achieved.

The vendors who performed the fixation indicated that it would be feasible to achieve a leachate concentration lower than 1 mg/l total arsenic by increasing the amount of proprietary agent added to the fixation formulation (Falk and Gironda - Telephone Communication, 1988). As the sediment has a high organic content, the amount of carbon added to the formulation would also be increased. Therefore, based on confirmation by the vendor, it is assumed, with EPA Region II concurrence, that the contaminated sediment could be fixated to achieve an EP Toxicity concentration of less than 0.32 mg/l total arsenic. This would enable the fixated wastes to be disposed of in a nonhazardous landfill.

It is also believed that the arsenic concentration in the separated coarse sands could be reduced, as a result of extraction, to levels complying with the VHS model. Extraction was evaluated in the bench-scale treatability studies to determine the feasibility of this technology to extract arsenic from the sediments. It was unclear from the tests whether the water wash simply separated the fine sediment containing arsenic from the coarse sediments which contain little arsenic, or whether the water actually solubilized the arsenic contained in the sediment. It is expected, based on the treatability study and other data collected during the RI, that the water wash separated the fine sediments that contained most of the arsenic from the coarse sediments. The elutriate solution, containing both fine sediments and water, contained a majority of the arsenic while the washed sediments contained very little arsenic (36 mg/kg). Therefore, a water "extraction" is deemed feasible to separate the coarse from the fine sediments, which in effect substantially reduces the arsenic concentration in the coarse sediments. It is believed that these course sediments could be delistable and thus disposed in a nonhazardous landfill.

These hypotheses are further supported by the fact that all the EP Toxicity tests conducted on <u>untreated</u> sediment achieved an extract of less than 0.32 mg/l total arsenic. For this FS, it is thus assumed that the treated sediments are delistable and can be disposed of in a nonhazardous landfill. This assumption is made with EPA Region II concurrence.

EPA Headquarters SPGB personnel also provided guidance on the criteria that the treated sediments from Union Lake would have to meet to allow for disposal in a hazardous waste RCRA Type C landfill. Since no BDAT is presently available for K031 listed hazardous waste, which the Union Lake sediments are considered to be, a "treatability variance" could be applied for in the event that the treated sediments do not meet the 0.32 mg/l arsenic concentration in an EP Toxicity test. For the treated Union Lake sediments, this treatability variance is 1 mg/l arsenic concentration in an EP Toxicity test. Achieving this level would allow the sediments to be disposed of in a RCRA Type C (hazardous waste) landfill.

To summarize, BDAT levels for the RCRA listed hazardous waste K-031 are not now established. The Union Lake sediments containing elevated arsenic concentrations are considered to be K-031 waste based on their being contaminated by K-031 wastes generated at the ViChem site.

Certain requirements governing the disposal of the K031 wastes will be established by May, 1990 or these wastes cannot be disposed of at all on the land. However, since these disposal criteria are not now established, EPA Headquarters SPGB personnel have given the following guidance to EPA Region II regarding the disposal options for the treated Union Lake sediments:

- If, after treatment, the treated sediments will comply with the substantive delisting criteria, the UHS model, then Region II can assume that the treated sediments will be delistable. For the quantity of treated sediments that will be generated from Union Lake, the UHS model specifies that the EP Toxicity leachate arsenic concentration must be less than 0.32 mg/l to pass this delisting criteria. If the treated sediments are delisted, they can be disposed in a nonhazardous waste landfill.

- If, after treatment, the treated sediments will not comply with the UHS model criterion of 0.32 mg/l in the EP Toxicity extract, then they cannot be disposed in a nonhazardous landfill. A treatability variance of 1 mg/l arsenic in the EP Toxicity leachate can be applied for. If the treated sediments can meet this level, but cannot meet the 0.32 mg/l criterion, then the treated sediments can be disposed of as hazardous waste in a RCRA Subtitle C landfill.

- If, after treatment, the treated sediments will not comply with the 1 mg/l treatability variance EP Toxicity criterion, they cannot be disposed of in any type of landfill and an alternate technology must be chosen that can achieve this minimum level.

Based on the treatability studies, information collected during the RI, and on information supplied by vendors, it is assumed that both fixation and water wash extraction can be optimized such that the treated sediments from either process will be delistable. This assumption is used with EPA Region II concurrence, based on what is now known about the Union Lake sediments. Bench or pilot-scale treatability studies to achieve optimized treatment systems must be performed as part of the design to verify this assumption and begin the delisting procedure.

3.1.2 Combination of Applicable Technologies into Feasible Remedial Alternatives

An overview of the technology screening presented in Section 2.0 and Table 3-3 indicates that three basic remedial alternatives exist for the contaminated sediments:

1) No Action

2) Removal, Treatment and Disposal

3) Containment (On-Site RCRA Landfill)

The development of the remedial alternatives is based on the identification and screening of technology types and process options as discussed in Chapter 2.0. Regulatory requirements require that a No Action Alternative be developed in order to serve as a baseline against which the other alternatives can be compared. The screening performed in Chapter 2 identified the arsenic-contaminated sediments to be treatable utilizing sediment fixation or extraction, with subsequent on-site or off-site disposal of the treated sediments. Alternatives 2A, 2B, 3A, and 3B were developed considering this option. As pointed out above, it is assumed that these treated sediments will be delistable, therefore they can be disposed in nonhazardous landfills (either on-site or off-site). Alternative 2C and 3C address sediment treatment utilizing fixation and extraction, respectively, with deep lake deposition of the treated sediments. Off-site RCRA and on-site RCRA disposal options for the untreated contaminated sediments are evaluated in Alternatives 4A and 4B. Alternative 5C is a containment alternative that evaluates covering the contaminated areas of Union Lake with a coarse sand layer.

Based on the requirements of the remedial action objective and associated feasible remedial technologies, the following combined remedial alternatives are thus identified:

Alternative 1 - No Action

Alternative 2A - Dredging/Thickening/Fixation/Off-Site Nonhazardous Landfill

Alternative 2B - Dredging/Thickening/Fixation/On-Site Nonhazardous Landfill

Alternative 2C - Dredging/Thickening/Fixation/Deep Lake Deposition

Alternative 3A - Dredging/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Alternative 3B - Dredging/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Alternative 3C - Dredging/Extraction/Deep Lake Deposition for Sediments/Off-Site Hazardous Sludge Disposal

Alternative 4A - Dredging/Dewatering/Off-site RCRA Landfill

Alternative 4B - Dredging/Dewatering/On-Site RCRA Landfill

Alternative 5 - In-Situ Sand Covering

3.1.3 Evaluation Criteria and Approach

The factors considered in the three evaluation criteria (i.e., effectiveness, implementability and cost) are discussed in the USEPA's March 1988 Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. A brief description of these factors is given below.

Effectiveness Evaluation

The effectiveness evaluation considers the capability of each remedial alternative to protect human health and the environment and to achieve the target cleanup concentrations. The target arsenic cleanup level sediments is 120 mg/kg. To be disposed in a nonhazardous landfill, the treated sediments must have an EPA Toxicity concentration of less than 0.32 mg/l arsenic. Each alternative is evaluated as to the protection it would provide, and the reductions in toxicity, mobility or volume it would achieve.

Implementability Evaluation

The implementability evaluation is used to measure both the technical and administrative feasibility of constructing, operating and maintaining a remedial action alternative. In addition, the availability of the technologies involved in a remedial alternative is also considered.

Cost Evaluation

The cost evaluation includes estimates of capital costs, annual operation and maintenance (O&M) cost, and present worth analysis. These conceptual cost estimates are order-of-magnitude estimates, and have been prepared based on:

- o Preliminary conceptual engineering for major construction components; and

- o Unit costs of capital investment and general annual operation and maintenance costs available from EPA documents (EPA 1985b and EPA 1985c) and from Ebasco in-house files.

Present worth costs are used for comparisons among the remedial alternatives, and they are estimated based on a designed discount rate and a system life. Note that treatment and nontreatment alternatives (containment and no action) are not compared with respect to cost, as they inherently do not provide similar degrees of remediation.

As a result of the screening process, effectiveness, implementability and present worth costs are then used to compare the alternatives, especially alternatives that are very similar. As a result of this comparison, the least favorable remedial alternatives are ruled out from further consideration or detailed evaluation. The alternatives that pass this screening are taken into detailed evaluation in Section 4.

3.2 DESCRIPTION AND SCREENING OF REMEDIAL ALTERNATIVES

The purpose of this section is to describe and screen the remedial action alternatives developed in Section 3.1.2 to narrow the number of potential remedial alternatives for detailed analysis while preserving a range of options. Screening criteria conform with remedy selection requirements set forth in CERCLA as amended, Section 121, and in the NCP (40 CFR 300.68 (g)).

3.2.1 Alternative 1 - No Action

Description: The No Action Alternative provides the baseline against which other responses can be compared. It would result in leaving the arsenic-contaminated sediments intact. The minimal action would consist of environmental monitoring and security measures. In addition, education programs would be implemented to inform the public about potential hazards.

A long-term monitoring program for Union Lake would include sediment sampling and lake water sampling. The site security measures would include posting warning signs and implementing institutional controls only. Fencing of a 870-acre lake would be ineffective and impractical. Because this alternative results in wastes remaining on-site, 1986 CERCLA amendments would require that the site be reviewed every five years.

Effectiveness: This alternative would reduce the potential for direct human contact (through the institutional controls of lake water uses); however, access restriction measures can be violated. This alternative would not achieve any reduction in the volume, toxicity or mobility of contaminants. Since this response does not address the threat of the off-site migration of contaminants, the contaminants may migrate off-site by leaching or through the resuspension of particles into lake water with subsequent discharge downstream.

Implementability: From a technical perspective, this alternative would be easy to implement (posting warning signs), but extensive site monitoring would require attention to long-term administrative feasibility considerations. Some administrative effort would also be required to obtain institutional controls. These institutional controls would include public education programs to heighten public awareness concerning the restricted use of the lake. Monitoring technologies are reliable and readily available.

Cost: No action would be the least expensive source control alternative under consideration. It is estimated that this alternative would require a capital cost of approximately $3,000 and an annual operation and maintenance cost of approximately $40,000 (per year for 30 years). The present worth cost for this alternative would be approximately $618,000 based on 5% interest for 30 years.

Conclusion: The No Action Alternative will be retained for detailed evaluation as it serves primarily, but not always, as a baseline for comparison with other remedial alternatives. This alternative is critical in the development of a range of source control alternatives.

3.2.2 Alternative 2A - Dredging/Thickening/Fixation/ Off-Site Nonhazardous Landfill

Description: Figure 3-1 depicts the contaminated areas representing health risks in Union Lake. Hydraulic dredging was identified in the initial screening investigation as the only practicable method for removing contaminated sediments from the lake. A Mud Cat* hydraulic dredging unit or an equivalent would be used to dredge an average depth of 1.0 ft of sediment and to pump the dredged sediment to the fixation plant for subsequent treatment and disposal. The volume of contaminated sediments to be dredged is estimated to be 130,000 cubic yards. Figure 3-2 shows a schematic of the treatment system.

A treatment plant for contaminated sediment fixation and supernatant treatment would be constructed at the site. The hydraulically dredged sediment, which would contain approximately 20% solids, would be pumped to the gravity thickeners to allow the separation of water and solids and thickening of the settled sediment. It is estimated that the dredged 351,000 cy (at a 20% solids content) would be reduced in

---

* In this report, any mention of the trade names of commercial products and processes does not constitute endorsement or recommendation for use.

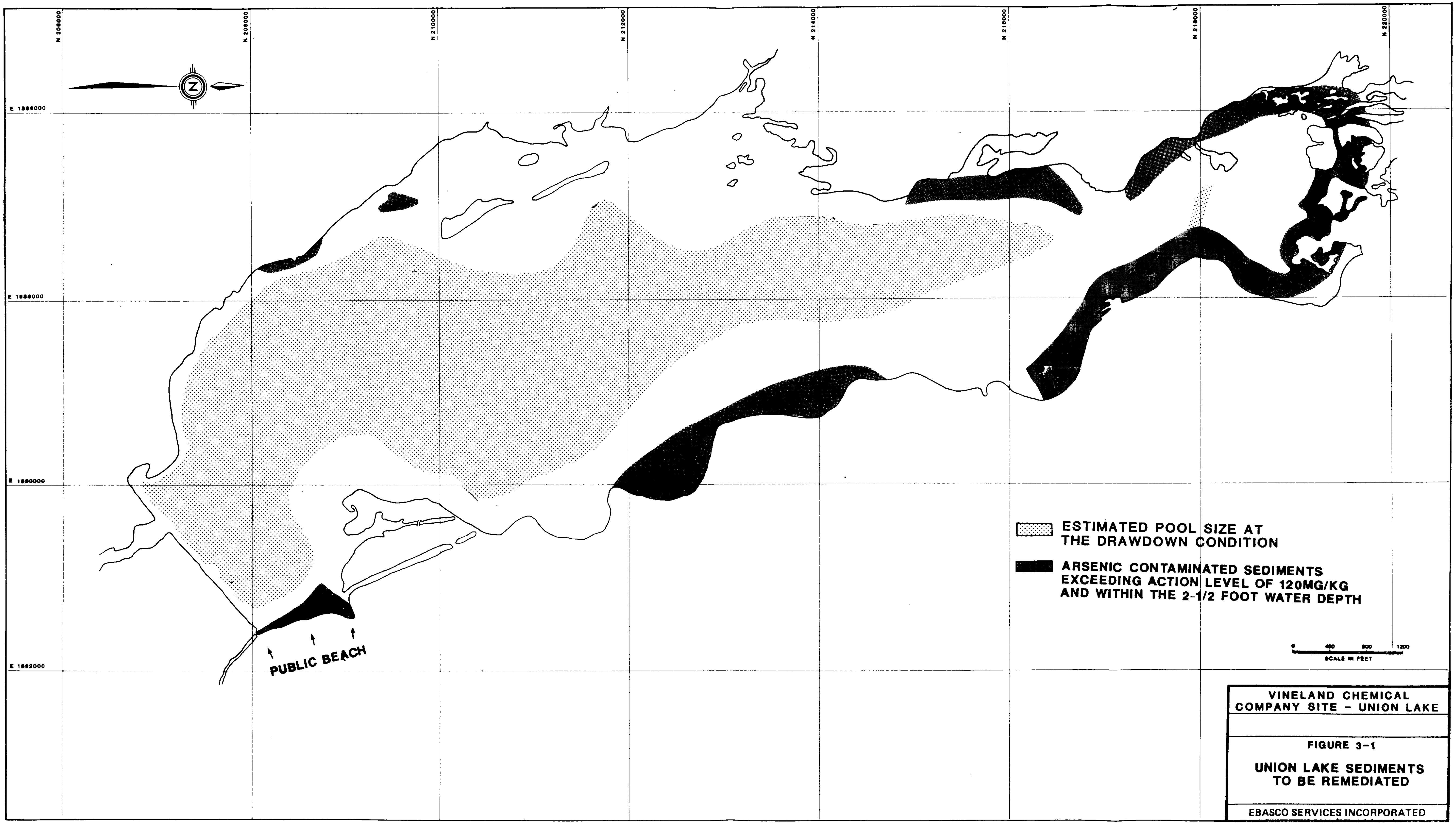
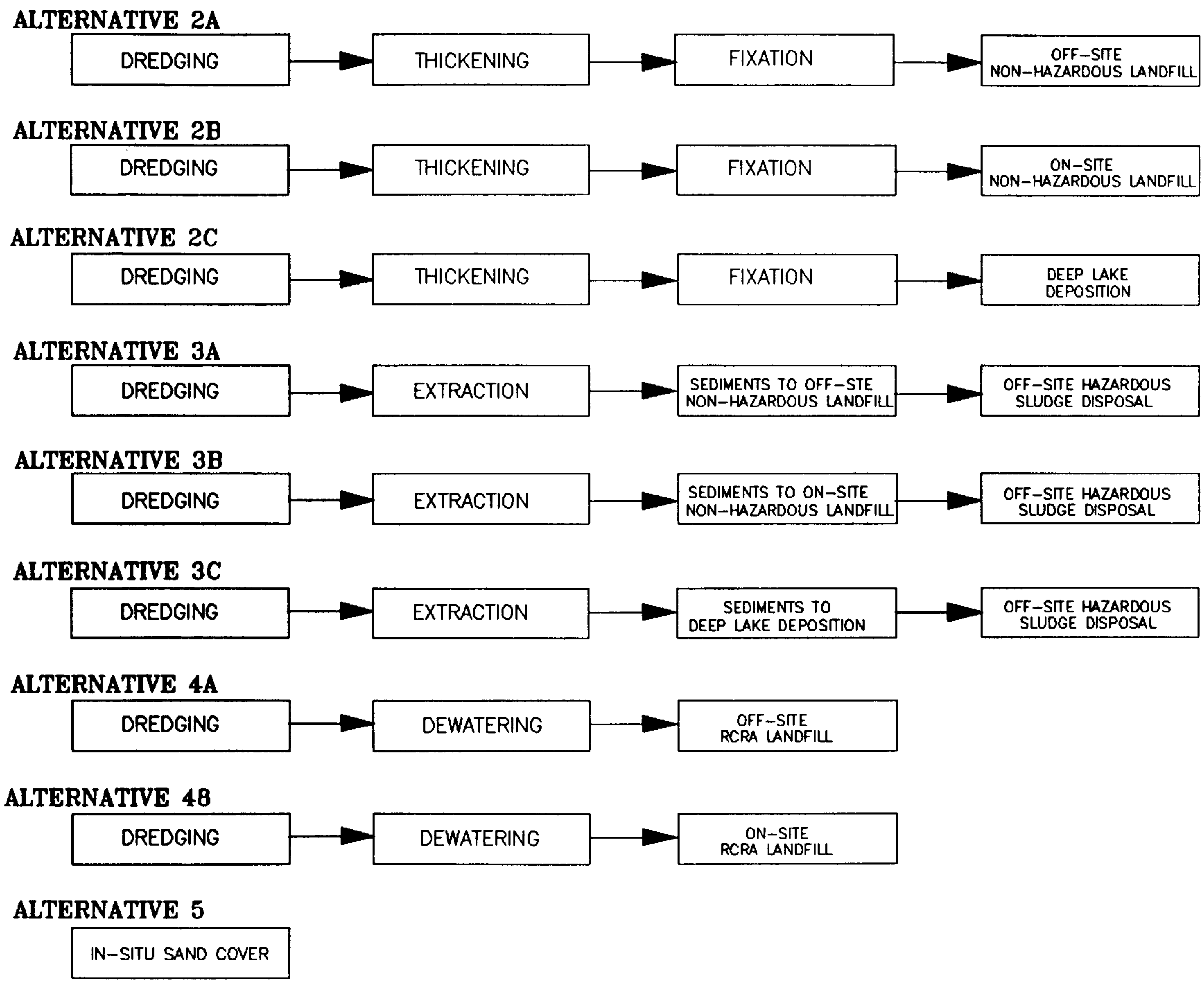

N 206000
N 208000
N 210000
N 212000
N 214000
N 216000
N 218000
N 220000
E 1886000
E 1888000
E 1890000
E 1892000
Z
PUBLIC BEACH
ESTIMATED POOL SIZE AT THE DRAWDOWN CONDITION
ARSENIC CONTAMINATED SEDIMENTS EXCEEDING ACTION LEVEL OF 120MG/KG AND WITHIN THE 2-1/2 FOOT WATER DEPTH
0 400 800 1200
SCALE IN FEET
VINELAND CHEMICAL COMPANY SITE - UNION LAKE
FIGURE 3-1
UNION LAKE SEDIMENTS TO BE REMEDIATED
EBASCO SERVICES INCORPORATED

FIGURE 3-2
SCHEMATICS OF SOURCE CONTROL TREATMENT ALTERNATIVES



volume to approximately 175,600 cy at a 40% solids content after settling and thickening. The settled sediment would then be withdrawn from the thickeners to a fixation unitwhere chemicals would be added to the contaminated sediment to chemically stabilize/immobilize the arsenic. After curing for more than 48 hours, the fixated sediments would be trucked to a nearby nonhazardous landfill site for disposal. It is assumed that the fixated sediments would be delistable.

The supernatant from the gravity thickeners would be discharged to the clarifiers for removal of total suspended solids (TSS). Alum, ferric chloride and polymer would be added as coagulants in this clarification and precipitation process. After the removal of TSS and arsenic, the levels of other associated parameters such as iron would also be significantly reduced to a level no greater than that in the ambient water. The sludge would be combined with the sediment to be fixated. The treated effluent would be discharged to the Union Lake.

The feasibility of the sediment fixation and supernatant treatment was evaluated during bench-scale studies as discussed in Section 6.0 of the Remedial Investigation (RI) report.

Reviews would be required every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative.

Effectiveness: Chemical fixation would achieve a permanent remedy for the dredged sediments by immobilizing arsenic contaminants and would minimize the potential for leachate generation. This alternative would achieve the target cleanup objective of 120 mg/kg in those areas identified as having contaminated sediments that pose a public health risk. Removal, treatment and off-site disposal of these sediments would eliminate the source of health risk. However, sediments with arsenic concentrations greater than 120 mg/kg remain in the lake under more than 2.5 feet of water. The dynamics of the lake could redistribute contaminated sediments into clean remediated areas.

No adverse effects are anticipated with implementation of this remedial alternative. Trucks would be used for transporting the treated sediment to a nearby municipal landfill site. Additional traffic would cause noise and air pollution and a possible increase in accidents in the surrounding areas of the site. These potential adverse impacts can be minimized by appropriate preventive measures, such as covering the wastes and decontaminating the trucks.

Implementability: Chemical fixation is a well-developed and reliable technology. The chemical additives for fixation and immobilization are commercially available, and the process equipment can be assembled using conventional off-the-shelf hardware. The fixation system could be designed and constructed for specific use at the site.

It is assumed that the fixated material would be delistable and could be disposed of in a nonhazardous landfill facility as discussed in Section 3.1.1.2. Therefore the alternative would not trigger the LDR.

Cost: The capital cost and annual operation and maintenance cost are estimated at $53,094,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a rate of 5%, is $53,709,000.

Conclusion: Chemical fixation of wastes addresses the current statutory preference for permanent remedies designed to reduce the mobility of wastes. This alternative would remove contamination from the site. Thus this alternative is retained for detailed evaluation.

3.2.3 Alternative 2B - Dredging/Thickening/Fixation/ On-Site Nonhazardous Landfill

Description: The operations involved in this alternative would be the same as those of Alternative 2A except that the fixated sediments would be disposed of at a newly constructed on-site nonhazardous landfill. In addition, reviews would be conducted every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative. Figure 3-2 shows a schematic of the treatment system.

As discussed in Alternative 2A, it is believed that the fixated waste would be delistable and therefore could be disposed of in a nonhazardous landfill according to regulatory requirements. Therefore, this on-site landfill would be constructed and operated according to the requirements specified in the New Jersey Solids and Hazardous Wastes Management Regulations.

An interpretation of the term "on-site" given to EPA Region II by EPA Headquarters SGPB personnel states that a landfill would be considered "on-site" only if it was constructed at the ViChem plant site. A landfill constructed near Union Lake would be considered off-site. In this report an on-site landfill refers to one that would be constructed at the ViChem plant site itself.

Effectiveness: The same screening concerns about effectiveness with implementing Alternative 2A can be applied to this alternative, except that additional environmental and public health impacts may be associated with the construction of the on-site nonhazardous landfill.

The ViChem plant site is not a sensitive ecosystem area such as a wetlands area. On-site landfilling of treated sediments would pose little risk to groundwater and surface water qualities due to the low mobility of fixated sediments and the effectiveness of the landfill system. The long-term hazard from the failure of the landfill system is unlikely. Therefore there are no appreciable environmental impacts for this landfill site.

Implementability: The same implementability screening concerns discussed in Alternative 2A can be applied to this alternative. In addition, the constructibility and reliability concerns associated with the construction of an on-site nonhazardous landfill are applicable to this alternative. The construction techniques for capping systems, liner systems, drainage systems and leachate collection systems are conventional and relatively simple. As the ViChem site is a CERCLA site, the permitting requirements are waived. The land is assumed to be available but it may not meet the local zoning regulatory requirements. Administrative efforts would be required to coordinate activities between state and local agencies.

It is assumed that the treated material could be delisted and disposed in a nonhazardous landfill. Since the material would be considered nonhazardous, land disposal restrictions would not apply.

EPA Headquarters SPGB informed EPA Region II that since the landfill would be on-site, a formal delisting petition to EPA Headquarters would not be necessary. The Region II Regional Administrator could choose this alternative based on information that the treated sediments were delistable, and would not have to petition Headquarters. The Regional Administrator could, however, be asked to provide information for considering the treated materials nonhazardous by EPA Headquarters.

Cost: The capital cost and annual operation and maintenance cost are estimated at $44,788,000 and $228,000 (per year for 30 years), respectively. The present worth cost, calculated at a rate of 5%, is $48,293,000.

Conclusion: This alternative would provide the same permanence of remedy as Alternative 2A. On-site nonhazardous landfilling of the treated sediments is viable and enables this alternative to be retained for detailed evaluation.

3.2.4 Alternative 2C - Dredging/Thickening/Fixation/Deep Lake Deposition

Description: The operations involved in this alternative would be the same as those of Alternative 2A except that the fixated sediments would be disposed of in Union Lake. Figure 3-2 shows a schematic of the treatment system.

The product of the sediment fixation is a physically stable solid with a rock-like appearance. The fixated product would be transported by barge to a deep area of Union Lake and deposited. The rock-like fixated sediments would sink to the bottom of the lake with a significant portion of the material submerging into the soft sediments.

Long-term monitoring would be required to measure the effectiveness of this alternative.

Effectiveness: The same effectiveness concerns with implementing Alternative 2A can be applied to this alternative except that additional environmental impacts may be associated with the deep lake deposition of the fixated sediments. Fixation of the sediments would significantly reduce the mobility of the arsenic. The long-term hazard from the failure of the fixation process is unlikely. However, adverse impacts may occur to the habitats of biota, fish and wildlife.

Implementability: The same implementability concerns in Alternative 2A can be applied to this alternative. In addition, the concerns associated with deep lake deposition are included. Transporting the fixated sediments by boat to the deep area of Union Lake would be relatively simple. However, there is no feasible means of monitoring the effectiveness of the fixation once the material is deposited into the lake. Further, if it were determined that the fixation technology failed and the material leached appreciable amounts of arsenic, it would be very difficult to recover the material because deposition would occur in a deep portion of the lake and within soft sediments.

Cost: The capital cost and annual operation and maintenance cost are estimated at $38,013,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a rate of 5%, is $38,628,000.

Conclusion: Deep lake deposition of the treated sediments is eliminated from further evaluation due to the inability to monitor the effectiveness of this alternative.

3.2.5 Alternative 3A - Dredging/Extraction/Sediments to Off-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal

Description: Arsenic-contaminated sediments would be hydraulically dredged. Mechanical soil washing with water would be provided to remove arsenic from the sediments. The extracted sediments would be placed on trucks and transported to an off-site nonhazardous landfill. Clean fill would be brought on-site and deposited in dredged areas. Reviews would be conducted every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative.

Extractant from the soil washing process would be treated in a system that would include the unit operations of chemical oxidation, coagulation, clarification, sedimentation and filtration.

It is estimated that 10,220 tons of arsenic contaminated sludge would be generated. The arsenic contaminated sludge would be transported to an off-site RCRA facility for treatment and disposal. Figure 3-2 shows a schematic of the treatment system.

Effectiveness: This alternative includes treating contaminated sediments with water in a reactor vessel. The treatment, after an optimum period of time, desorbs arsenic from the sediments and/or separates fine organics containing arsenic as solids in a solution from coarse sediments containing very little arsenic. The effectiveness of this technology would depend on the extent to which arsenic is extracted from the sediments with the water. The treatability studies indicated that water would remove most of the arsenic from the overall sediment (2,780 mg/kg cleaned to 34 mg/kg after removing fines and/or desorbing arsenic). A pilot-scale test would be required to confirm the effectiveness of this technology. It is expected that the treated sediment would be delistable, and thus could be safely deposited in an off-site nonhazardous landfill.

The concentration of the extracted arsenic dissolved in the wastewater would be reduced to below the MCL of 50 ug/l by chemical oxidation, coagulation/clarification and filtration. This process would also separate fine organics containing arsenic from the solution. As the wastewater would meet MCL's, it could be discharged to Union Lake.

This remedial alternative would attain the health-based cleanup target level of 120 mg/kg by reducing the toxicity and mobility and volume of the contaminated sediments that were identified as a public health risk in the risk assessment. A long-term monitoring progam would be required to measure the effectiveness of this alternative. There are no long-term adverse impacts on public health and the environment resulting from the implementation of this remediation.

Implementability: Soil washing/extraction systems utilize available equipment from the process industries, and the reliability is generally high from an operation and maintenance standpoint. Mobile type soil washing/extraction systems are currently commercially available. The EPA operates a mobile soil washing unit that is capable of processing 4 to 18 cubic yards of soil per hour depending on the soil properties and the optimum period of reaction. Extraction systems are not complex and can be assembled using conventional off-the-shelf hardware. The system could be designed and constructed for specific use at the site.

Similarly, the extractant treatment systems are conventional industrial wastewater physical-chemical treatment processes that can be designed and constructed for specific uses utilizing conventional off-the-shelf hardware. These technologies are well developed and highly reliable.

It is expected that the extracted sediment would be delistable based on EP Toxicity test results of untreated sediments and the VHS model as discussed in Chapter 3, and thus could be disposed of in a nonhazardous landfill facility. Since the material would be nonhazardous and thus delistable, land disposal restrictions would not apply. The wastewater containing the fine sediments would be treated to MCL levels and would also be delistable. The arsenic-contaminated sludge generated from the extraction process would be transported to a RCRA treatment and disposal facility and treated according to BDAT requirements. The sludge would ultimately be disposed of in a RCRA Subtitle C Landfill in accordance with the land ban. It is assumed that the EP Toxicity concentration of the treated sludge would comply with the 1 mg/l arsenic leachate treatability variance.

Cost: The capital cost and annual operation maintenance cost are estimated at $27,876,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a rate of 5%, is $28,491,000.

Conclusion: Water extraction of arsenic provides permanent remedies to remove arsenic contamination from the sediments excavated from the lake. This alternative would reduce the toxicity, mobility and volume of wastes and is retained for detailed evaluation.

3.2.6 Alternative 3B - Dredging/Extraction/ Sediments to On-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal

Description: The operations involved in this alternative would be the same as those of Alternative 3A except the processed sediments would be disposed of in an on-site nonhazardous landfill because the treated sediments would be expected to comply with the hazardous waste delisting criteria. The on-site landfill facility would be constructed as described in Alternative 2B. Figure 3-2 shows a schematic of the treatment system.

Effectiveness: Both the effectiveness of water extraction discussed in Alternative 3A and the effectiveness of an on-site nonhazardous landfill discussed in Alternative 2B are applicable for this alternative. The water extraction would significantly reduce the level of arsenic concentration in the sediment to meet the hazardous waste delisting criteria, so that the treated sediment could be safely deposited in an on-site nonhazardous landfill facility. The on-site nonhazardous landfill would not pose any appreciable environmental impacts to surface water, groundwater and the ecosystem at the site.

The extractant water would be treated utilizing conventional industrial wastewater treatment units as discussed in Alternative 3A. Arsenic concentration in the wastewater would be reduced to meet MCLs. The arsenic contaminated sludge would be transported to a RCRA treatment and disposal facility.

Implementability: As discussed in Alternative 3A, mobile soil-washing/extraction systems are currently commercially available. A large-scale chemical extraction system could be designed and constructed for specific use at the site. The extractant treatment systems are conventional wastewater treatment processes and could be designed and constructed for site-specific uses.

The implementability of an on-site nonhazardous landfill facility discussed in Alternative 2B is applicable for this alternative. A long-term monitoring program would be required at the landfill site.

As discussed in Alternative 3A, the clean soil would be expected to be delistable and could be disposed of in a nonhazardous landfill. RCRA land disposal restrictions would therefore not apply to this material. An on-site nonhazardous landfill would be constructed on the ViChem property adjacent to the plant. As this is a CERCLA site, the permit requirements are waived. The extractant treatment system would reduce the arsenic concentration water to levels below MCLs, enabling disposal to Union Lake. The arsenic-contaminated sludge would be transported to a RCRA treatment and disposal facility.

Cost: The capital cost and annual operation and maintenance cost are estimated at $22,890,000 and $228,000 (per year for 30 years), respectively. The present worth cost, calculated at a 5% rate, is $26,395,000.

Conclusion: This alternative would provide the same permanent remedies as Alternative 3A. It would require the construction of an on-site landfill and the implementation of a long-term monitoring program. This alternative is retained for further evaluation.

3.2.7 Alternative 3C-Dredging/Thickening/Extraction Deep Lake Deposition for Sediments/Off-Site Hazardous Sludge Disposal

Description: The operations involved in this alternative would be the same as those of Alternative 3A except the treated sediments would be disposed of deep in Union Lake. No long-term management program would be required.

Due to the nature of the sediments in Union Lake, the product of the extraction process would be a clean, coarse sand. The sand would be transported to a deep portion of Union Lake by barges equipped with pneumatic pumps for dry solids, then deposited. Figure 3-2 shows a schematic of the treatment system.

Effectiveness: The effectiveness of water extraction as discussed in Alternative 3A is applicable for this alternative. Water extraction would significantly reduce the level of arsenic contamination in the sediment. Based on EP Toxicity test results of untreated sediment and the results of the VHS model, as discussed in Chapter 3, the treated sediment could be delisted and safely deposited in the lake.

Deep lake deposition of the coarse sand may cause environmental impacts to the lake ecosystem. Adverse impacts may occur to the habitats of biota, fish and wildlife.

Implementability: As discussed in Alternative 3A, mobile soil washing/extraction systems are currently commercially available. Large-scale extraction systems could be designed and constructed for site-specific use. The extractant treatment system utilizes conventional industrial wastewater treatment processes that are well developed and highly reliable.

As discussed previously, it is assumed that the extracted sediments would be delistable and could be disposed of in a non-hazardous landfill. The sludge generated from the extraction process would be transported to a RCRA treatment and disposal facility.

Cost: The capital cost and annual operation and maintenance costs are estimated to be $19,175,000 and $40,000 (per year for 30 years), respectively. The present worth, calculated at a 5% rate, is $19,790,000.

Conclusion: This alternative would provide a permanent remedy for removing arsenic contamination from the sediments identified as a public risk in the risk assessment. Therefore this alternative is retained for further evaluation.

3.2.8 Alternative 4A - Dredging/Dewatering/Off-Site RCRA Landfill

Description: The tasks of sediment dredging and gravity thickening involved in this alternative would be the same as those described in Alternative 2A, except that the settled sediment would be withdrawn from the gravity thickeners to a vacuum filter for further dewatering. The dewatered sediment would contain approximately 30 to 35% solids that would be suitable for landfill deposition. If necessary, the dewatered sediment would be stabilized by mixing it with inert additives such as kiln dust. The supernatant from the gravity thickeners and the vacuum filter would be treated utilizing clarification and precipitation process units as described in Alternative 2A. Figure 3-2 shows a schematic of the treatment system.

The off-site RCRA landfill would include containerization and transportation of the arsenic contaminated sediment to a commercial RCRA hazardous landfill site.

Effectiveness: This alternative would consist of hydraulic dredging, dewatering, transporting and landfilling the sediments and treatment of the supernatant. The on-site dredging and dewatering operations would include removal of the source material and subsequent consolidation into containers for off-site transportation. A permitted RCRA disposal facility with the capacity and capability to handle this source material must be identified. Off-site disposal is preferable when on-site disposal is precluded or limited by site characteristics.

This alternative eliminates any future on-site release from source material and eliminates contaminant exposure to humans and animals. It also would allow the unimpaired use of Union Lake for recreational purposes.

This alternative would be effective at eliminating waste sources, leachate generation and contaminant migration from the removed sediments. Long-term monitoring would be required to monitor redistribution patterns of the sediments.

This alternative would attain the health-based cleanup target level of 120 mg/kg arsenic in sediments from shallow areas and would achieve a reduction in toxicity, mobility and volume of contaminants in the lake. However, it would not reduce the toxicity and volume of contaminated sediments in the environment. The off-site RCRA landfill would reduce the mobility of the arsenic contaminants by containment. If the landfill should fail, the contaminants could be re-released into the environment. In addition, the RCRA land disposal restrictions regulation (51 CFR 40572, November 7, 1988) would require that contaminated sediments be treated via the Best Demonstrated Available Technology (BDAT) prior to placement in an off-site RCRA facility. ARARs pertaining to land disposal restrictions would not be attained since the wastes would not be treated.

Implementability: This remedial alternative has been demonstrated at many small hazardous waste sites. There should be no special difficulties in removing and transporting the sediment and restoring the site. The major obstacles to implementing the alternative are identifying the disposal facilities capable of accepting the large volume of waste material and the associated cost of transport and disposal (i.e., RCRA landfill availability and capacity).

Implementation of this alternative would require an administrative effort to secure an off-site RCRA landfill for disposal. With the implementation of the RCRA LDR, this may be very difficult. Land disposal restrictive regulations and DOT regulations for waste shipment would need to be met.

Off-site disposal of sediment from contaminated areas is a feasible option if an acceptable facility can be identified. The only currently recognized permanent land disposal facility is a double lined landfill. There are very few commercial facilities with double liners in the eastern United States capable of receiving the large volume of wastes that would be removed from the site. Implementation of this alternative would depend on the available capacity and the current laws that would prevail at the time of remediation.

Cost: The capital cost and annual operation and maintenance cost are estimated at $58,864,000 and $40,000 (per year for 30 years), respectively. The present worth cost, calculated at a rate of 5%, is $59,479,000.

Conclusion: The off-site disposal of contaminated soils without any treatment would not meet the land disposal restriction requirements. This alternative is therefore not feasible at this site.

3.2.9 Alternative 4B - Dredging/Dewatering/On-Site RCRA Landfill

Description: The operations involved in this alternative would be the same as those of Alternative 4A, except that the dredged and dewatered sediments would be disposed of at a newly constructed on-site RCRA landfill. A new RCRA Subtitle C containment facility could be constructed on the ViChem plant site. This potential landfill area is considered to be within the site boundaries as discussed previously.

The RCRA landfill would have to be designed with a double liner system and have two leachate detection, collection and removal systems, and a groundwater monitoring program, according to applicable RCRA requirements. Figure 3-2 shows a schematic of the treatment system.

Effectiveness: Even though landfilling hazardous waste was widely used as a management practice for years, it is now being discouraged by EPA, which makes obtaining approval for construction of a new facility very difficult. The on-site RCRA landfill alternative would remove hazardous wastes from the area of contamination into another area within the Superfund site boundaries. This on-site landfill would constitute RCRA land disposal, thus the land disposal restriction requirements would be applicable for this alternative. As discussed in Alternative 4A, ARARs pertaining to land disposal restrictions would not be attained since wastes would not be treated prior to being placed in a RCRA facility.

The RCRA landfill would provide only a long-term containment for the hazardous waste, but would not attain permanent remedy designed to reduce the toxicity, mobility and volume of wastes. Since the contaminated sediments would be removed from Union Lake, risks to recreational users of the lake, leachate generation, and contaminant migration from sediments to lake water would be reduced. The on-site RCRA landfill would not pose any appreciable environmental impacts to surface water, groundwater and the ecosystem around the landfill site. A long-term operation and maintenance management plan, including periodic groundwater monitoring, would be required for the post-closure activities.

Implementability: The RCRA landfill facility could be designed to satisfy all the applicable requirements. The potential landfill site would not be within the 100-year floodplain. The construction of a landfill facility is a conventional and proven technology and would be commercially available. The possibility of failure of a new RCRA landfill system is relatively low. The land is assumed to be available; however, local zoning regulatory requirements may not be met.

Landfilling hazardous wastes without any treatment is unlikely to be acceptable to the community and approvable by the State. The permitting process requires extensive investigations and acceptance by regulatory agencies. Important factors affecting the regulatory acceptance would be the site conditions, design, construction, operation, public uneasiness, closure, and post-closure monitoring. In addition, the acquisition of the area property may be difficult.

Cost: The capital cost and annual operation and maintenance cost are estimated at $17,764,000 and $298,400 (per year for 30 years), respectively. The present worth cost, calculated at a rate of 5%, is $22,351,000.

Conclusion: The on-site hazardous waste landfill without any pretreatment may not be acceptable to the State and community. This alternative would not meet the land disposal restriction requirements. Therefore it is eliminated from further evaluation for the site.

3.2.10 Alternative 5 - In-Situ Sand Covering

Description: This remedial alternative would involve the covering of contaminated sediments within Union Lake with a layer of coarse sand. Coarse sand would be transported to the site by trucks, and either transferred to barges equipped with pneumatic pumps for dry solids or dumped from the trucks and graded. Coarse sand would be uniformly spread at predetermined areas to form a one-foot-thick layer atop those selected contaminated sediments. It is estimated that approximately 130,000 cubic yards of coarse sand would be required to cover approximately 81 acres of contaminated sediment with a one-foot depth. Figure 3-2 shows a schematic of the treatment system.

Effectiveness: A one-foot sand covering atop those selected contaminated sediments would temporarily reduce the potential threats to public health via direct contact and ingestion of the contaminated sediments. Thus this alternative would reduce the risks via the sediment exposure pathways.

The covering of sediments that exceed the action level in shallow water would not reduce any toxicity or volume of the contamination sources, and may slightly reduce the physical mobility of the sources. This remedial alternative would not achieve the target cleanup level of 120 mg/kg established for the lake sediments. Sand covering would not eliminate leaching and the migration of arsenic from the sediments to the lake water. The covering would, however, tend to minimize the physical migration or movement of the sediments. In addition, covering a portion of the lake shoreline with a one-foot sand cover may have an environmental impact on the lake ecosystem. Adverse impacts may occur to the habitats of biota, fish and wildlife.

A one-foot blanket of coarse sand on top of the contaminated sediments within the two-and-a-half foot water depth may not be permanent due to natural dynamic water movement, human disturbance during swimming, jogging, or children digging in the sand, growth of vegetation, or wind-induced erosion during low water periods. These potential mechanisms for erosion and cover disturbance would therefore require a long-term monitoring and maintenance program.

Implementability: Coarse sand is a common construction material readily available locally. Trucks, front-end loaders, and/or pneumatic pumping for the sand layer installation are conventional techniques and are relatively simple to implement. The constructibility of this alternative is very high, while the reliability is low. The construction time is estimated at approximately six months. Annual monitoring would be required for the useful public life of the lake to ensure that the one-foot sand layer is maintained in those predetermined areas, and that contaminants or sediments are not migrating into new areas. This alternative would not trigger RCRA LDR requirements, as no sediments are removed, treated, or disposed from the lake.

Cost: The capital cost and annual operation and maintenance costs are estimated at $2,600,000 and $40,000 (per year for 30 years), respectively. The present worth, calculated at a 5% discount rate, is $3,215,000.

Conclusion: Although this alternative does not achieve any reduction in toxicity or volume of the contaminated sediments, it may slightly reduce the mobility of contaminants. The alternative may not provide a permanent solution for the problems identified. However, in the event that USEPA does not set a BDAT standard for #K031 wastes and the waste cannot be delisted, this alternative would be a relatively low-cost remedial action that would minimize health risks and would not trigger LDR restrictions. In-situ sand covering is retained for further evaluation.

3.3 SUMMARY OF INITIAL SCREENING OF REMEDIAL ALTERNATIVES

Tables 3-1 and 3-2 present a summary of the conceptual costs and summaries of the alternative screening processes that were presented in Section 3.2. Conclusions from these tables are given below.

TABLE 3-1

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL SOURCE CONTROL ALTERNATIVES

Potential Source Control Alternatives	Major Remediation Components	Estimated Quantities	1988 Dollars: Unit Cost	1988 Dollars: Capital Cost	1988 Dollars: Annual O/M Cost
1. Alternative 1 - No Action	1. Warning Signs	75	$100	$ 7,500	
	2.	40	$1,000		$40,000/yr
			Total	$ 7,500	$40,000/yr
2. Alternative 2A - Dredging/ Thickening/Fixation/Off-Site Nonhazardous Disposal	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,500	
	2. Gravity Thickening	71 x 10^6 gal	$ 0.05/1,000 gal	$ 3,550	
	3. Supernatant Water Treatment	57 x 10^6 gal	$ 0.5/1,000 gal	$ 28,500	
	4. Chemical Fixation	175,600 cy	$ 200/cy	$35,120,000	
	5. Off-Site Transport	174,000 tons	$ 40/ton	$ 6,960,000	
	6. Off-Site Nonhazardous Landfill	174,000 tons	$ 50/ton	$ 8,700,000	
	7. Quarterly Monitoring				$40,000/yr
			Total	$53,094,000	$40,000/yr
3. Alternative 2B - Dredging/ Thickening/Fixation/On-Site Nonhazardous Landfill	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,500	
	2. Gravity Thickening	71 x 10^6 gal	$ 0.05/1,000 gal	$ 3,550	
	3. Supernatant Water Treatment	57 x 10^6 gal	$ 0.5/1,000 gal	$ 28,500	
	4. Chemical Fixation	175,600 cy	$ 200/cy	$35,120,000	
	5. On-Site Nonhazardous Landfill	115,900 cy	$ 60/cy	$ 6,954,000	$180,000/yr
	6. Land	8 Acres	$50,000/acre	$ 400,000	
	7. Post Landfill Monitoring	16	$500		$ 8,000/yr
	8. Quarterly Monitoring			$	$ 40,000/yr
			Total	$44,778,000	$228,000/yr
4. Alternative 2C - Dredging/ Thickening/Fixation Deep Lake Deposition	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,500	
	2. Gravity Thickening	71 x 10^6 gal	$0.05/1,000 gal	$ 3,550	
	3. Supernatant Water Treatment	57 x 10^6 gal	$0.05/1,000 gal	$ 28,500	
	4. Chemical Fixation	175,600 cy	$ 200/cy	$35,120,000	
	5. Deep Lake Deposition	115,900 cy	$ 5/cy	$ 579,500	
	6. Quarterly Monitoring				$40,000/yr
			Total	$38,013,000	$40,000/yr

TABLE 3-1 (Cont'd)

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL SOURCE CONTROL ALTERNATIVES

Potential Source Control Alternatives	Major Remediation Components	Estimated Quantities	1988 Dollars Unit Cost	Capital Cost	Annual O/M Cost
5. Alternative 3A - Dredging/ Extraction/Sediments to Off-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,000	
	2. Gravity Thickening	71×10^6 gal	$ 0.05/1,000 gal	$ 3,550	
	3. Water Treatment	57×10^6 gal	$ 0.5/1,000 gal	$ 28,500	
	4. Chemical Extraction	175,600 cy	$ 80/cy	$14,048,000	
	5. Extractant Treatment	16×10^6 gal	$ 4/1,000 gal	$ 64,000	
	6. Off-Site Transport	105,000 ton	$ 40/ton	$ 4,200,000	
	7. Off-Site Nonhazardous Landfill	105,000 ton	$ 50/ton	$ 5,250,000	
	8. Sludge Disposal	10,000 ton	$ 200/ton	$ 2,000,000	
	9. Quarterly Monitoring				$40,000/yr
			Total	$27,876,000	$40,000/yr
6. Alternative 3B - Dredging/ Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,500	
	2. Gravity Thickening	71×10^6 gal	$ 0.05/1,000 gal	$ 3,550	
	3. Supernatant Water Treatment	57×10^6 gal	$ 0.5/1,000 gal	$ 28,500	
	4. Extraction	175,600 cy	$ 80/cy	$14,048,000	
	5. Extractant Treatment	16×10^6 gal	$ 4/1,000 gal	$ 64,000	
	6. On-Site Nonhazardous Landfill	70,240 cy	$ 60/cy	$ 4,214,000	$180,000/yr
	7. Land	5 acres	$ 50,000/acre	$ 250,000	
	8. Post Landfill Monitoring	16	$ 500		$ 8,000/yr
	9. Sludge Disposal	10,000 ton	$ 200/ton	$ 2,000,000	
	10. Quarterly Monitoring				$ 40,000/yr
			Total	$22,890,000	$228,000/yr
7. Alternative 3C - Dredging/Extraction/ Deep Lake Deposition of Sediments/ Off-Site Hazardous Sludge Disposal	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,000	
	2. Gravity Thickening	71×10^6 gal	$ 0.05/1,000 gal	$ 3,550	
	3. Water Treatment	57×10^6 gal	$ 0.5/1,000 gal	$ 28,500	
	4. Chemical Extraction	175,600 cy	$ 80/cy	$14,048,000	
	5. Extractant Treatment	16×10^6 gal	$ 4/1,000 gal	$ 64,000	
	6. Deep Lake Deposition	75,000 cy	$ 10/cy	$ 750,000	
	7. Sludge Disposal	10,000 ton	$ 200/ton	$ 2,000,000	
	8. Quarterly Monitoring				$40,000/yr
			Total	$19,175,000	$40,000/yr

TABLE 3-1 (Cont'd)

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL SOURCE CONTROL ALTERNATIVES

Potential Source Control Alternatives	Major Remediation Components	Estimated Quantities	1988 Dollars: Unit Cost	1988 Dollars: Capital Cost	1988 Dollars: Annual O/M Cost
8. Alternative 4A - Dredging/ Dewatering/Off-Site RCRA Landfill	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,500	
	2. Gravity Thickening	71×10^6 gal	$ 0.05/1,000 gal	$ 3,550	
	3. Supernatant Water Treatment	57×10^6 gal	$ 0.5/1,000 gal	$ 28,500	
	4. Dewatering System (Vacuum Filters)	130,000 cy	$ 10/cy	$ 1,300,000	
	5. Blending/Storage	130,000 cy	$ 5/cy	$ 650,000	
	6. Off-Site Transportation	195,000 tons	$ 80/ton	$15,600,000	
	7. Off-Site RCRA Landfill	195,000 tons	$ 200/ton	$39,000,000	
	8. Quarterly Monitoring				$ 40,000/yr
			Total	$58,864,000	$ 40,000/yr
9. Alternative 4B - Dredging/ Dewatering/On-Site RCRA Landfill	1. Hydraulic Dredging	351,000 cy	$ 6.5/cy	$ 2,281,500	
	2. Gravity Thickening	71×10^6 gal	$ 0.05/1,000 gal	$ 3,550	
	3. Supernatant Water Treatment	57×10^6 gal	$ 0.5/1,000 gal	$ 28,500	
	4. Dewatering System (Vacuum Filters)	130,000 cy	$ 10/cy	$ 1,300,000	
	5. Blending/Storage	130,200 cy	$ 5/cy	$ 650,000	
	6. On-Site RCRA Landfill	130,000 cy	$ 100/cy	$13,000,000	$250,400/yr
	7. Land	10 acres	$ 50,000/acre	$ 500,000	
	8. Post Landfill Monitoring	16	$ 500		$ 8,000/yr
	9. Quarterly Monitoring				$ 40,000/yr
			Total	$17,764,000	$298,400/yr
10. Alternative 4C - In-Situ Sand Covering	1. Coarse Sand Cover Installation	130,000 cy	$ 20/cy	$ 2,600,000	
	2. Quarterly Monitoring	40	$ 1,000		$ 40,000/yr
			Total	$ 2,600,000	$ 40,000/yr

TABLE 3-2

SUMMARY OF SOURCE CONTROL (SEDIMENT) ALTERNATIVE SCREENING

Source Control Alternatives	Cost (Million Dollar 1989) Capital	Annual O/M	Present Worth	Effectiveness	Implementability	Detailed Evaluation
NO ACTION						
Alt. 1 - No Action	0.003	0.04	0.62	1. Minimize access to contaminated sediment source areas by signs and public education 2. Does not attain ARARs 3. No reduction in toxicity, mobility or volume	1. Easy implementation 2. Monitoring technologies are reliable and available 3. State approval and community acceptance are questionable	Retained
TREATMENT						
Alt. 2A - Dredging/Thickening/Fixation/Off-Site Nonhazardous Disposal	53.09	0.04	53.71	1. Achieve permanence of remedy in those sediments identified as a public health threat 2. Reduces mobility of contaminants 3. Treated material is believed to be delistable 4. Short-term potential public health and environmenal impacts due to handling and transportation 5. Facilitate lake restoration for public use 6. Does not attain all ARARs 7. Long-term adverse impacts could occur if significant redistribution of the contaminated sediments occurs 8. Requires pilot scale study to confirm effectiveness	1. Chemical fixation is well developed and reliable technology 2. Full-scale operation of fixation is commercially available 3. Treatability studies proved fixation is a feasible technology 4. Potential impacts on public health and environment can be minimized by providing health/safety protection measures 5. Off-Site nonhazardous landfill facilities are commercially available 6. Long-term post-implementation management is required to measure effectiveness of this alternative	Retained
Alt. 2B - Dredging/Thickening/Fixation/On-site Nonhazardous Landfill	44.79	0.228	48.29	1. Same as Items, 1, 2, 3, 5,6,7 and 8 in Alt. 2A 2. Long-term environmental impacts due to on-site landfill would be possible boundaries would be possible; 3. Transportation impacts would be minimized	1. Same as Items 1,2,3,4, and 6 in Alt. 2A 2. Nonhazardous landfill technology is conventional and available 3. State approval and community acceptance of on-site nonhazardous landfill is required	Retained

9483b

TABLE 3-2 (Cont'd)

SUMMARY OF SOURCE CONTROL (SEDIMENT) ALTERNATIVE SCREENING

Source Control Alternatives	Cost (Million Dollar 1989) Capital	Annual O/M	Present Worth	Effectiveness	Implementability	Detailed Evaluation
Alt. 2C - Dredging/Thickening/Fixation/Deep Lake Disposal	38.01	0.04	38.63	1. Same as Items 2,3,5,6 and 8 in Alt. 2A 2. Long-term environmental impacts on the lake possible if fixation process fails 3. Minimize transportation through populated areas	1. Same as Items 1, 2, and 3 in Alt. 2A. 2. Transportation by Barge is conventional and readily available 3. Long-term post implementation management is required 4. Impossible to monitor effectiveness of fixation process 5. If fixation process fails, no feasible method to recover fixated material	Eliminated
Alt. 3A - Dredging/Extraction/Sediments to Off-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal	27.88	0.04	28.49	1. Same as Items, 1, 4, 5, 6, 7 and 8 in Alt. 2A 2. Reduce mobility and toxicity of contaminants in sediments 3. Treated sediments believed to be delistable 4. Sludge generated from extraction process would be treated and disposed of at an off-site RCRA Facility	1. Extraction is well developed and reliable technology 2. Full-scale operation of extraction is commercially available 3. Treatability studies obtain the target level (120 mg/kg) 4. Extractant treatment process is a well-developed technology 5. The implementation facilities require a considerable space	Retained
Alt. 3B - Dredging/Extracttion/Sediments to On-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal	22.89	0.228	26.40	1. Same as Items, 1, 4, 5, 6, 7 and 8 in Alt. 2A 2. Same as Items 2, 3 and 4 in Alt. 2A 3. Possible long-term environmental impacts on the landfill area 4. Minimize transportation impacts on the environment	1. Same as Items 1, 2, 3, 4, and 5 in Alt. 3A 2. Nonhazardous landfill technology is conventional and available 3. State approval and community acceptance required for on-site nonhazardous landfill	Retained
Alt. 3C - Dredging/Extraction/Deep Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal	19.18	0.04	19.79	1. Same as Items 1, 4, 5, 6, 7 and 8 in Alt. 2A 2. Same as items 2, 3 and 4 in Alt. 3A 3. Possible long-term environmental impacts on lake due to deep lake deposition of the treated sediments.	1. Same as Items 1,2,3,4 and 5 in Alt. 3A 2. Deep lake deposition would be a simple technology	Retained

9483b

TABLE 3-2 (Cont'd)

SUMMARY OF SOURCE CONTROL (SEDIMENT) ALTERNATIVE SCREENING

Source Control Alternatives	Cost (Million Dollar 1989) Capital	Annual O/M	Present Worth	Effectiveness	Implementability	Detailed Evaluation
CONTAINMENT						
Alt. 4A - Dredging/Dewatering/Off-Site RCRA Landfill	58.86	0.04	59.48	1. Landfill does not attain SARA requirements 2. Landfill without treatment does not meet RCRA land disposal restriction requirements 3. Landfill does not achieve any reduction in volume or toxicity but may reduce mobility of contaminant on-site 4. Potential public health and environmental impacts due to handling and transportation	1. RCRA landfill is demonstrated and proven technology 2. Commercial RCRA landfill facilities are limited and require intensive administrative efforts 3. No long-term post-implement management is required 4. Dewatered sediments may require stabilization for off-site transportation and landfill	Eliminated
Alt. 4B - Dredging/Dewatering/On-Site RCRA Landfill	17.76	0.30	22.35	1. Same as Items 1, 2, 3 as Alt. 4A 2. Long-term environmental impacts on the landfill areas would be possible 3. Minimize transportation impacts on the environment	1. Same Items 1, 4 as Alt 4A 2. State approval and community acceptance for on-site hazardous landfill is questionable 3. Long-term post-implementation management is required	Eliminated
Alt. 5 - In-Situ Sand Covering	2.60	0.04	3.22	1. Sand covering does not attain ARARs by reducing in toxicity, mobility or volume of waste 2. Sand cover does not provide total reliable prevention of direct contact and ingestion risks 3. Adverse impacts on lake ecosystem 4. Potential erosion and disturbance and needs long-term maintenance 5. Cost effective alternative	1. Implementation is relatively simple and available 2. Local traffic control and air pollution control are required 3. Sand covering is not stable and needs long-term administrative control	Retained

1) Extraction of arsenic contaminants from the sediments would reduce the volume, toxicity and mobility of contaminants, whereas fixation only offers a reduction of mobility.

2) RCRA landfilling of the arsenic wastes would not provide a permanent remedy. Since no reduction in toxicity, mobility or volume would be achieved, Alternatives 4A and 4B are eliminated from detailed evaluation.

3) Off-site nonhazardous landfilling of the treated sediment may be more implementable than on-site landfilling due to state and community approval required for construction of a landfill. However, a cost savings is realized in utilizing an on-site landfill for disposal.

4) Deep lake deposition of extracted sediments is a viable cost effective method of disposal and is retained for further evaluation.

5) Sand covering is a cost effective alternative that would minimize public health risks and environmental impacts and is retained for detailed evaluation.

A summary of the alternatives screened in this section and the results of the screening process are provided below.

Alternative	Description	Results
1	No Action	Retained
2A	Dredging/Thickening/Fixation/ Off-Site Nonhazardous Landfill	Retained
2B	Dredging/Thickening/Fixation/ On-Site Nonhazardous Landfill	Retained
2C	Dredging/Thickening/Fixation/ Deep Lake Deposition	Eliminated
3A	Dredging/Extraction/Sediments to Off-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal	Retained
3B	Dredging/Extraction/Sediments to On-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal	Retained
3C	Dredging/Extraction/Deep Lake Deposition for Sediments/ Off-Site Hazardous Sludge Disposal	Retained

Alternative	Description	Results
4A	Dredging/Dewatering/Off-Site RCRA Landfill	Eliminated
4B	Dredging/Dewatering/On-Site RCRA Landfill	Eliminated
5	In-Situ Sand Covering	Retained

4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents a detailed evaluation of each remedial alternative that passed the initial screening in Section 3.0. Table 4-1 lists the alternatives to be analyzed in this section. Section 4.1 discusses the evaluation process used and the nine (9) criteria against which the alternatives are analyzed. The nine criteria are:

1. Short-Term Effectiveness
2. Long-Term Effectiveness
3. Reduction of Toxicity, Mobility or Volume
4. Implementability
5. Cost
6. Compliance with ARARs
7. Overall Protection of Human Health and the Environment
8. State Acceptance
9. Community Acceptance

Section 4.2 discusses the assessment of the remedial alternatives in which each alternative is described in detail and evaluated with respect to each of the nine criteria listed above.

4.1 EVALUATION PROCESS

The remedial alternatives are examined with respect to the requirements stipulated in CERCLA as amended, OSWER Directive No. 9355.0-19 (Interim "Guidance on Superfund Selection of Remedy", December 24, 1986), statutory factors described in OSWER Directive No. 9355.0-21 ("Additional Interim Guidance for FY'87 Records of Decision", July 24, 1987) and EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, March 1988). A detailed analysis of alternatives consists of the following components and processes:

- Further definitions of each alternative, if appropriate, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.

- Assessment and summary of each alternative against the nine criteria as defined by the OSWER Directive No. 9355.0-21.

- Comparative analysis among alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

TABLE 4-1

DETAILED RANGE OF SOURCE CONTROL REMEDIAL ALTERNATIVES

Alternative 1:	No Action
Alternative 2A:	Dredging/Thickening/Fixation/Off-Site Nonhazardous Landfill
Alternative 2B:	Dredging/Thickening/Fixation/On-Site Nonhazardous Landfill
Alternative 3A:	Dredging/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
Alternative 3B:	Dredging/Extraction/Sediment to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
Alternative 3C:	Dredging/Extraction/Deep Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal
Alternative 5:	In-Situ Sand Covering

Each remedial alternative is evaluated with respect to the nine criteria presented below. At the completion of all detailed analyses, a summary section is included, whereby the statutory factors and criteria described in OSWER Directive No. 9355-021 are compared for each alternative to assist in the remedy selection process.

Short-Term Effectiveness: This evaluation criterion addresses the impacts of the alternative during the construction and implementation phase until the remedial action objective is met. Factors to be evaluated include protection of the community during remedial actions; protection of workers during the remedial actions; environmental impacts resulting from the implementation of the remedial actions; and the time required to achieve protection.

Long-Term Effectiveness: This evaluation criterion addresses the results of the remedial action in terms of the risk remaining at the site after the response objectives have been met, particularly the effectiveness of the controls that will be applied to manage the risk posed by treatment residuals and/or untreated wastes. The components of this criterion include the magnitude of the remaining risk measured by numerical standards such as cancer risk levels; the adequacy and suitability of controls used to manage treatment residuals or untreated wastes; and the long-term reliability of management controls for providing continued protection from residuals, i.e., the assessment of potential failure of the technical components.

The evaluation of the risks in this category will consider sediment exposure risks only. As discussed previously, there are existing increased health risks from exposure to the surface water and from ingesting fish. These risks will not necessarily be reduced through sediment remediation. However, the surface water risks may be reduced by stopping the source of arsenic entering the rivers, thereby reducing the water's arsenic concentrations. The fish ingestion risks may be reevaluated in the future. In either case, since sediment remediation is the focus of this FS, the risks associated with the sediments themselves will be the focus of the risk reduction for this evaluation criterion.

Reduction of Toxicity, Mobility or Volume: This evaluation criterion addresses the statutory preference that treatment is used to reduce the principal threats of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of the total volume of contaminated media. Factors of this criterion to be evaluated include the treatment process employed; the amount of hazardous material destroyed or treated; the degree of reduction in toxicity, mobility, and volume expected; and the type and quantity of treatment residuals.

Implementability: This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. Factors of technical feasibility include construction and operation difficulties, the reliability of technology, the ease of undertaking additional remedial action and the ability to monitor the effectiveness of the remedy. The administrative feasibility includes the ability and time required for permit approval and activities needed to coordinate with other agencies. Factors to evaluate the availability of services and materials include the availability of treatment, storage and disposal services with the required capacities; the availability of equipment and specialists; and the availability of prospective technologies for competitive bids.

Cost: The types of costs that should be addressed include capital costs, operation and maintenance (O&M) costs, costs of five year reviews (where required), the present value of capital and O&M costs and potential future remedial action costs. Capital costs consist of direct and indirect costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install the remedial actions. Indirect costs include expenditures for engineering, financial, and other services required to complete the installation of the remedial alternatives. Other annual O&M costs include auxiliary materials and energy, disposal of residues, purchased services, administrative costs, insurance, taxes, and license costs, maintenance reserve and contingency funds, rehabilitation costs and the costs of periodic site review.

This assessment evaluates the costs of remedial alternatives on the basis of present worth. Present worth analysis allows remedial alternatives to be compared on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. A required operating performance period is assumed for present worth and is a function of the discount rate and time. A discount rate to 5 percent is assumed for a base calculation. The "study estimate" costs provided for the alternatives are intended to reflect actual costs with an accuracy of -30 to +50 percent.

Compliance with ARARs: This evaluation criterion is used to determine how each alternative complies with applicable or relevant and appropriate federal and state requirements as defined in CERCLA Section 121. Each alternative is evaluated in detail for:

- o Compliance with chemical-specific ARARs (e.g., MCLs)
- o Compliance with action-specific ARARs (e.g., RCRA minimum technology standards)

- o Compliance with location-specific ARARs (e.g., preservation of historic sites)
- o Compliance with appropriate criteria, advisories, and guidances

Table 4-2 presents a list of ARARs and "to be considered" (TBC) material that were used to evaluate the remedial alternatives. The table entries provide specific statutory or regulatory citations and their applications to the remedial alternatives evaluated in Section 4.2.

Overall Protection of Human Health and the Environment: This evaluation criterion provides an overall assessment of protection based on a composite of factors such as long-term and short-term effectiveness and compliance with ARARs. Evaluations of the overall protectiveness address:

- o How a specific alternative achieves protection over time
- o How risks are reduced
- o How each source of contamination is to be eliminated, reduced, or controlled for each alternative

State Acceptance: This assessment evaluates the technical and administrative issues and concerns the state may have regarding each of the alternatives. Factors of state acceptance to be addressed include features the state supports, reservations of the state, and opposition of the state.

Community Acceptance: This assessment incorporates public input into the analysis of alternatives. Factors of community acceptance to be discussed include features the community supports, reservations of the community and opposition of the community.

Since the state and the public have not been provided with a formal opportunity to review the detailed analysis of the remedial alternatives, no formal comments from the state and the public are available for evaluation of the "State Acceptance" and "Community Acceptance" criteria in this FS report. It is anticipated that the formal comments from the state and the public will be provided during the 30-day public comment period for this FS report. These comments will then be addressed in the ROD and responsiveness summary. Therefore only the first seven evaluation criteria were used to evaluate the alternatives.

TABLE 4-2

ARARs AND "TBC" MATERIAL FOR REMEDIAL
ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Contaminant - Specific:		
o Federal Clean Water Act Quality Criteria	Source Control	Ambient Water Standards for Surface Water used by NJ to develop their own standards.
o New Jersey Environmental Cleanup Responsibility Act (ECRA) (ECRA-NJAC 7:103) New Jersey Soil Cleanup TBC for arsenic	Source Control	Soil cleanup action level
o NJ Surface Water Stds (NJAC 7:9-4, 14(c) and (d)	Source Control	Ambient stds for water treatment systems discharge-ing to surface water
Action - Specific:		
o Federal and NJ Hazardous Waste RCRA Treatment Storage and Disposal Facility Standards (40 CFR 264/265 and N.J.A.C. and 7:26-9, 10 and 11)	Source Control	General stds. for groundwater monitoring, closure, and post-closure activities
o Clean Water Act NJPDES Discharge to Surface Water Requirements (N.J.A.C. 7:14A-1 of seq. Appendix F)	Source Control	Stds. for water treatment systems discharging to surface water
		Design and operating stds., closure and post-closure activities for specific treatment systems

9484b

TABLE 4-2 (Cont'd)

ARARs AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Action-Specific (Cont'd)		- Landfills - "Miscellaneous" units such as soil leaching, extraction, ion exchange, fixation and other chemical, physical, and biological treatment systems
o Federal Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions	Source Control	BDAT required prior to land disposal of certain contaminated wastes
o Federal and NJ Non-hazardous (Sanitary) Landfill Stds. (40 CFR 257/258 and N.J.A.C. 7:26-2A and 2)	Source Control	Design and operating stds. for sanitary landfills
o Federal and NJ Transportation Requirements for Hazardous and Non-hazardous Waste (40 CFR 263 and N.J.A.C. 7:26-3 and 7)	Source Control	Off-site transport of treatment residues and excavated material
o OSHA-Recordkeeping, Reporting and Related Regulations	Source Control	General stds. outlining the recordkeeping, and reporting regulations

TABLE 4-2 (Cont'd)

ARARs AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Action-Specific (Cont'd)		
o OSHA Health and Safety Requirements for Hazardous Substance Responses (29 CFR 1910)	Source Control	Worker Protection stds. for all activities
o RCRA Characteristic Testing for Hazardous Waste Identification (40 CFR 261)	Source Control	EP Toxicity Test for determining whether a material is RCRA Hazardous
o RCRA-Contingency Plan and Emergency Procedures	Source Control	General stds. for emergency contingency plans
o DOT Transportation Requirements for Hazardous Waste (40 CFR 100 - 177)	Source Control	Manifest System for hazardous waste transport
o NJ Toxic Substances Air Pollution Stds (N.J.A.C. 7:27-17)	Source Control	General prohibition on discharge of pollutants to air from storage tanks
o NJ Ambient Air Quality Stds. (N.J.A.C. 7:27-13)	Source Control	Stds. for limiting discharge of certain particulates
Location - Specific:		
o NJ Soil Erosion and Sediment Control Act of 1975 (N.J.S.A. 4:24-42) and Guidance	Source Control	Vegetative and engineering stds. to control sedimentation and conserve soil
o Wild and Scenic Rivers Act	Source Control	

TABLE 4-2 (Cont'd)

ARARs AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

ARARs and "TBC" Material	Alternative Type Affected	Application
Action-Specific (Cont'd)		
o National Endangered Species Act	Source Control	Activities that affect endangered species
o US Fish and Wildlife Coordination Act	Source Control	Activities that affect fish or wildlife in stream areas
o Federal Floodplain and Wetlands Executive Order (#11990 and 11988) (40 CFR 6 Appendix A)	Source Control	Activities that affect flood plains and wetlands
o Federal Floodplain and Wetlands Policy (40 CFR 6, Appendix A)	Source Control	Activities that affect floodplains and wetlands
o New Jersey Coastal Area Facility Review Act (CAFRA) Permit Requirements (N.J.S.A. 13:19-1 et seq)	Source Control	Activities affecting coastal areas
o New Jersey Wetlands (Coastal and Fresh) Permit Requirements (N.J.S.A. 13:9A-1 et seq, and 13:98-1 et seq	Source Control	Activities affecting wetlands
o NJ Stream Encroachment Permit Standards (N.J.A.C. 7:8-3.15)	Source Control	Construction within 100-yr flood plain areas
o Rivers and Harbors Act Section 10 Clean Water Act Section 404 Stds	Source Control	Excavation activities in riverine areas may fall within "navigable waters of the US"

4.2 ASSESSMENT OF REMEDIAL ALTERNATIVES

Each source control (SC) alternative for the arsenic contaminated sediments in the Union Lake will be discussed in a separate subsection of Section 4.2. OSWER Directive No. 9355.0-19 recommends the development of SC alternatives ranging from an alternative that would eliminate the need for long-term management to alternatives involving treatment technologies to reduce the mobility, toxicity, or volume of contaminants. Containment options and a No-Action Alternative are also part of this range of SC alternatives.

Alternative 1 - No Action-involves limiting access to the site, conducting public education programs and instituting site-use restrictions. This alternative has no provisions for the treatment or containment of wastes. Alternatives 2A and 2B involve on-site treatment of arsenic-contaminated sediments by chemical fixation. The treated sediments would be landfilled as nonhazardous wastes off-site and on-site for Alternatives 2A and 2B, respectively. Alternatives 3A, 3B, and 3C involve on-site treatment of arsenic-contaminated sediments by chemical extraction (i.e., sediment water washing). The processed sediments would be landfilled as nonhazardous off-site and on-site for Alternatives 3A and 3B, respectively. Alternative 3C involves deep lake deposition of the water-washed sediments. Alternative 5 provides containment of the sediments utilizing a sand layer, but not treatment.

4.2.1 <u>Alternative 1 - No-Action</u>

4.2.1.1 Description

Under this alternative, a public education program would be provided and warning signs would be installed to minimize access to the site. Institutional administration would be established to limit the use of the Union Lake. Warning signs would be posted at 500-foot intervals around the perimeter of the lake at prominent locations. Education programs, including public meetings and presentations, would be undertaken to increase public awareness.

Long-term monitoring of the lake would be performed to evaluate the performance of this alternative. This would consist of annual inspections as well as sampling the sediments and lake water every year for 30 years. Sixteen sediment samples and four lake water samples would be collected yearly and analyzed for arsenic. In addition, an ecosystem survey conducted during a site visit would be performed yearly. Because this alternative would result in contaminants remaining on-site, CERCLA as amended requires that the site must be reviewed every five years.

The major work items associated with this alternative are:

- o Mobilize/demobilize
- o Install and maintain warning signs
- o Establish institutional control limiting the site use
- o Conduct annual inspection and water/sediments sampling to monitor contaminant concentrations and their migration
- o Conduct educational programs, including public meetings and presentations, to increase public awareness
- o Perform site review every five years

4.2.1.2 Assessment

o <u>Short-Term Effectiveness</u>: This No-Action Alternative would only restrict site access and use. No substantial construction would be involved in this remedial action. There are no short-term threats to neighboring communities and no significant impacts on public health and the environment during implementation activities. On-site workers would be properly protected with personal protection equipment against ingestion of contaminants during the implementation of this alternative. Therefore the risks through direct contact can be minimized. Education programs, including public meetings and presentations, would be presented to increase public awareness.

o <u>Long-Term Effectiveness</u>: The No-Action Alternative would not result in the near-term attainment of target cleanup levels. Many years may be required before natural degradative and transport mechanisms reduce the sediment arsenic concentration in the areas to be remediated to the target level of 1×10^{-5}.

The alternative would be designed to prevent ingestion and/or direct contact with the contaminated sediments by restricting access to the site. The long-term effectiveness of the alternative in minimizing baseline human health risks through the potential exposure pathways would depend on its success in preventing access to the site and use of the study area. The incremental lifetime cancer risks associated with direct contact to exposure to sediments in shallow areas containing greater than 120 mg/kg arsenic are now greater than 1×10^{-5}. If the access restrictions were unsuccessful, these risk levels might not decrease for many years.

This alternative would not improve the lake ecosystem. Additionally, the mobilization of arsenic contaminants from the sediments to the lake water may occur in the future.

There are no additional long-term threats to neighboring communities resulting from the implementation of this alternative.

- Reduction of Toxicity, Mobility or Volume: This alternative would not involve any containment, removal, treatment or disposal. It would leave the contaminated sediments in place. Therefore, this alternative would not result in any reduction in the toxicity or mobility of contaminants. The lake's natural degradative and transport mechanisms may resuspend, disperse, and possibly leach the sediments to lake water. Therefore there may be a reduction in the volume of contaminated sediments in the lake over time. However, assuming all future arsenic releases to the lake were stopped, it might take several years for the natural dynamics of the lake to significantly reduce the volume of contaminated sediments.

Implementability

- Technical Feasibility: Posting warning signs is a relatively simple task, which could be performed by local contractors. The required equipment is readily available. The work could be completed within a relatively short period of time.

  Once posted, warning signs would minimize site access. Routine inspection and replacement of missing signs would be performed. Direct monitoring of the effectiveness of the alternative may be difficult, since it is impossible to determine if complete access restriction is achieved. Public awareness would increase the effectiveness of this alternative and regular surveillance of the public would deter access violations.

- Administrative Feasibility: Implementation of this alternative would require institutional controls to restrict recreational use of the lake. Considerable long-term institutional management would be associated with this alternative because wastes would remain on- site and review would be necessary every five years. Annual inspections, sampling and public education programs (e.g., public meetings and workshops) would demand administrative and regulatory attention.

- Cost: The capital cost for this alternative, as outlined in Table B-1, is $44,500. Operation and maintenance costs for this alternative, outlined in Table B-8, are approximately $47,200 a year, for 30 years. The present worth, calculated at a rate of 5%, is $839,600. This cost represents all of the activities to post warning signs, implement institutional controls through public informing activities, and conduct six five-year reviews.

- Compliance with ARARs: ARARs for the No-Action Alternative apply to the posting of warning signs and the site monitoring activities. Requirements for these activities include OSHA Health and Safety Standards and RCRA facility standards.

  This alternative would not remove contaminated material from the site nor would it provide containment of contaminated sediment. It would provide only minimal protection to human health and the environment. It would provide only minimal protection to human health. All appropriate and relevant RCRA closure/post-closure requirements in 40 CFR 264.110 - 264.120 would not be met. The potential for the contaminants to migrate from the sediments into the lake water and the potential for human exposure to the contaminants would not be eliminated. As this is a No Action Alternative, it does not trigger LDR.

- Overall Protection of Human Health and the Environment

  The No-Action Alternative would not remove or contain the contaminated sediments, and therefore it would not be protective of human health and the environment. There would be no reduction in the toxicity or mobility of the contaminants. Many years may be required for the natural attenuation to reduce the arsenic concentration in the sediment in the shallow areas to below the cleanup level of 120 mg/kg, which corresponds to a cancer risk level of $1x10^{-5}$.

  This alternative is not considered responsive to the remedial objectives, but provides a "base case" for comparison between other alternatives.

- State Acceptance: No state comments have been received to date.

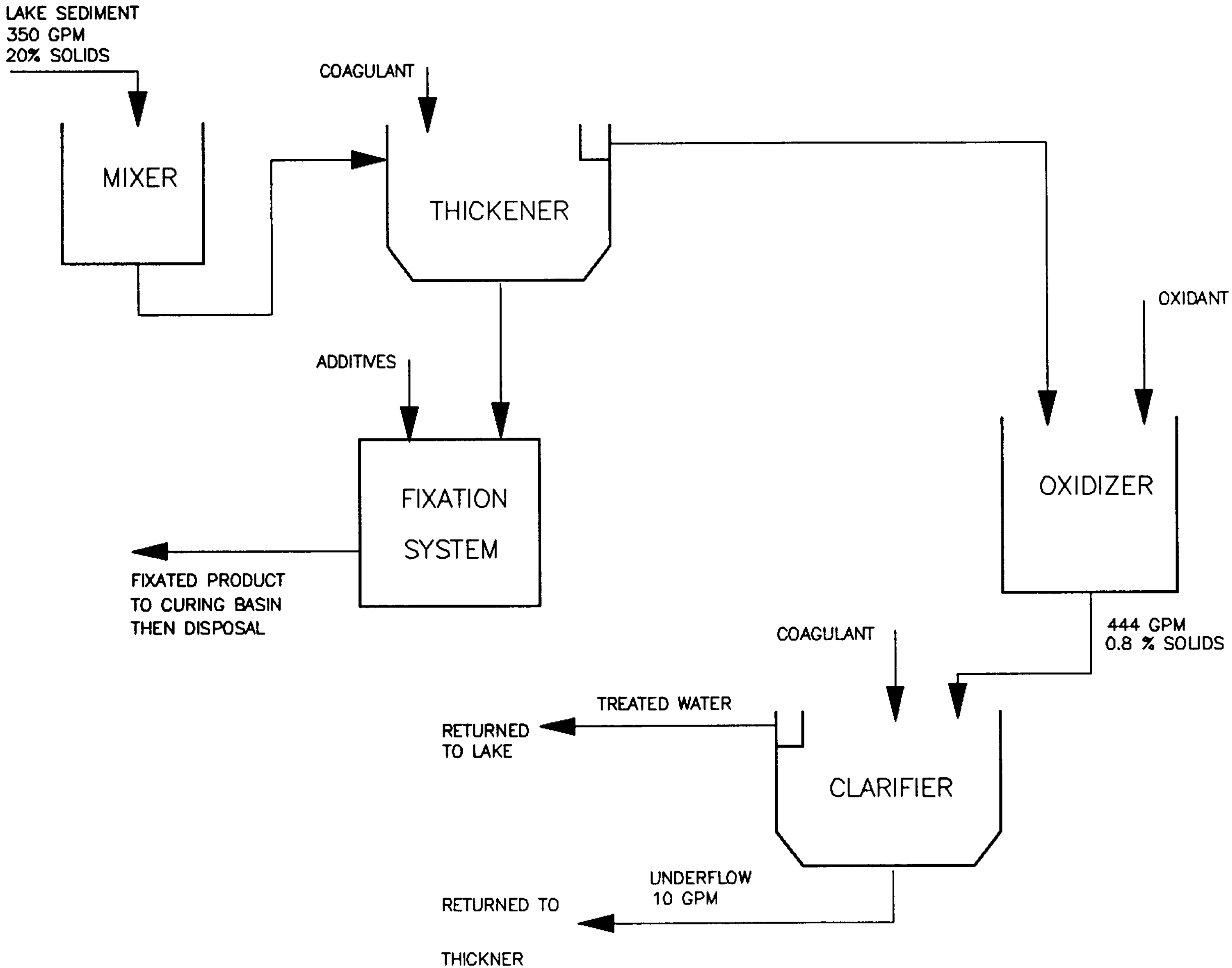
- Community Acceptance: No public comments have been received to date.

4.2.2 Alternative 2A - Dredging/Thickening/Fixation/ Off-Site Nonhazardous Landfill

4.2.2.1 Description

The major features of this alternative, as shown in Figure 4-1, include hydraulic dredging of contaminated sediments, sediment treatment and disposal, and supernatant water treatment and

FIGURE 4-1
FIXATION SYSTEM



discharge. This is a source control (removal/treatment) alternative in which the contaminated sediments are removed and fixated. The processed sediments can be disposed of in a nonhazardous landfill facility off-site.

o <u>Hydraulic Dredging</u>

Hydraulic dredging would be performed to remove contaminated sediment to a depth of approximately 1.0 ft. Hydraulic dredges remove and transport sediment in liquid slurry form containing approximately 10 to 20% solids by volume. It is expected that the lake water would provide a minimum water depth to maintain hydraulic dredge mobility.

A "portable" dredge is a type of hydraulic dredge that is designed for use in shallow bodies of water and industrial settling ponds, and is transportable by truck. One of the most widely used portable dredges is the Mud Cat* dredge, whose applications to date have included dredging small reservoirs, streams and industrial ponds. The Mud Cat is also known as a horizontal-auger dredge.

The Mud Cat is pontoon-mounted and features a horizontally mounted, auger-like cutting device that feeds the excavated sediment to a suction intake of a diesel-driven centrifugal pump producing an 8 ft-wide cut. The auger is mounted along the base of a bulldozer-type blade. The entire configuration, with suction pipe attached, is controlled by a hydraulic boom. The dredge is moved along on an anchored cable during each traverse of excavation, and the dredged material is discharged ashore through a float- supported pipeline.

The Mud Cat is considered to be the best dredge qualified for use in Union Lake and has been selected for the following reasons:

1. Small size - the Mud Cat can be transported to the site by a conventional tractor-trailer truck and placed in the water by crane.

2. Shallow draft - it draws just under 2 ft.

3. Low resuspension of sediments during dredging activities.

---

* In this report, any mention of trade names of commercial products and processes does not constitute endorsement or recommendation for use.

Two Mud Cats would dredge sediments at a rate of approximately 100 cubic yard of sediment/slurry per day, eight hours a day. Approximately 130,000 cubic yards of sediment (in place volume, assuming 54% solids and 46% water as in-place sediment density) would be removed by the Mud Cats over a period of about two years. The sediments would be pumped at a solids content of approximately 20% by volume. The total pumping rate of the water-sediment slurry with approximately 20% solids by volume would be approximately 350 gpm, or 175 gpm per Mud Cat. The slurry would be pumped through a floating piping system to an on-site treatment facility.

o <u>Sediment Chemical Fixation/Stabilization</u>

The sediment would be treated at a facility constructed on the designated site using the chemical fixation processes shown in Figure 4-1. The sediment would first be thickened in two (2) steel thickeners, each 42 feet in diameter and 10 feet high. The thickened sediments would be treated in mixing tanks using the fixation process. The fixated sediments would be cured in an on-site storage area for a specified period (approximately 48 hours) to complete the fixation/stabilization process.

Bench-scale tests were performed to prove the feasibility of chemical fixation for the contaminated sediment by utilizing a commercial proprietary "K-20/LSC" process. The "K-20 LSC" process is based upon a chemical treatment utilizing three components: thickened/dewatered sediments, a dry reagent and a liquid reagent. The dry reagent is made from Portland cement, fly ash and activated carbon powder. The liquid reagent is a commercial silicated blend known as K-20/LSC, which has been developed and manufactured by Lopat Enterprises, Inc. of Wanamassa, New Jersey. The K-20/LSC System has been demonstrated and proven to be effective, having the ability to be custom-blended as need for a particular application.

The sediment and dry reagent would be thoroughly blended in specially designed high-powered mixing tanks. After blending, the liquid reagent would be injected into the mass and further blending would take place. A rapid chemical reaction would occur, transforming the product into a gel. The gel would then be extruded into a confinement (curing basin) where it would be kept for 48 hours. The fixated product in the treatability test achieved an unconfined compressive strength (UCS) of approximately 9,000 psi, which significantly exceeded the required design strength of 1,500 psi.

The product of this process would be chemically fixated and physically stabilized. All constituents of concern, such as arsenic, would be bound within the K-20/LSC gel. The product would be a solid with a rock-like appearance and would be suitable for landfill disposal. Details of the test results are given in Section 6 and Appendix A of the Union Lake RI Report (Ebasco, 1988c).

- Supernatant Water Treatment

  The supernatant from the thickeners would be pumped into two clarifiers 20 ft in diameter by 10 ft high. Alum, ferric chloride and polymers would be added and mixed in order to remove suspended solids and reduce arsenic concentrations to below 0.05 mg/l. The clarified supernatant would be tested and returned to Union Lake via a discharging system. The settled solids from the clarifiers would be pumped back to the thickener tanks and would be treated in the same manner as the contaminated sediments. In order to optimize this system, a pilot-scale study would be required.

- Off-Site Nonhazardous Disposal

  The fixated sediment would be loaded onto trucks for transport to nearby nonhazardous solid waste landfills. The total volume of fixated sediment is estimated to be 116,000 cu yd, free of water. The trucks would be lined, sealed, weighed, manifested, and decontaminated prior to leaving the site.

  The major construction components and facilities for this alternative are outlined in Table A-2 of Appendix A.

4.2.2.2 Assessment

- Short-Term Effectiveness: The short-term effectiveness concerns with this alternative include public health threats, adverse impacts on the environment and the safety of workers during the implementation activities. The potential public health threats to area residents would include direct contact with spilled wastes and the inhalation of fugitive dust. The sediment treatment plant would be located, at a minimum, 500 feet away from the nearest recreational facility or house. The entire treatment plant would be fenced and warning signs would be posted. Access would be limited to authorized personnel only. The sources of fugitive dust emissions include dried sediment, cement and fly ash used in the fixation process. The storage and handling of these materials would be performed in a closed silo and in a vessel equipped with proper dust control devices. The fixated sediments waiting to be transported off-site would be contained to prevent further contamination. Therefore the short-term public health threats resulting from this remedial action would be minimal.

The hydraulic dredging operation would result in localized sediment resuspension and could temporarily affect biota. Since the hydraulic dredging would be limited to local shallow water areas, suspensions would settle in a short period of time, and fish and wildlife would have adequate room to avoid the disturbed area. The use of Union Lake would be suspended during the operation. The adverse effects on the lake ecosystem and the environment would be temporary and localized.

The on-site risk to workers would be minimized by the use of adequate preventive measures and proper protective equipment for personnel to prevent direct contact with wastes and the inhalation of fugitive dust. All unit operations such as dredging, thickening, fixation, curing and transportation would be performed with adequate containment (tanks, vessels and silos) and in confined areas. Any leachate or drainage generated from the curing basin would be collected and treated for suspended solids. The supernatant would be tested for arsenic prior to being discharged to the lake. The short-term risks to workers would be minimal.

The short-term impacts on the environment include increased traffic and construction operations in the area. The trucks transporting the fixated sediment would be decontaminated and covered, however the passage of trucks through the neighboring communities could have some impacts on them. Additional traffic could cause noise pollution, a possible increase in accidents and air pollution. On-site safety issues include the truck traffic, accidents, noise, and airborne particulates from transporting the fixed sediment. An appropriate local traffic control plan would be implemented by the local authorities. Proper dust control measures such as water spray would be provided to minimize air pollution.

The time required to complete this remedial action is estimated at approximately two years.

o <u>Long-Term Effectiveness</u>: Immobilization through chemical fixation methods is designed to render contaminants insoluble, prevent leaching from the fixated wastes, reduce the potential of direct human contact, and improve waste-handling characteristics. This alternative would not achieve any reduction in volume and toxicity, but would reduce the mobility of contaminants. Chemical fixation would convert contaminated sediments into a stable cement-type matrix free of water. The supernatant separated from the dredged sediments would be treated through the physical-chemical precipitation processes to remove arsenic below 0.05 mg/l (Safe Drinking Water Standards) prior to discharge to Union Lake.

The major long-term effectiveness concern would include the beneficial and adverse impacts on public health and the environment that might result from the completion of this remediation. The major benefits associated with this alternative is that sediments that have been determined as a public health risk (sediments with an arsenic concentration greater than 120 mg/kg and which underlie a water column depth of 2.5 feet or less) would be removed and treated. This action would reduce the potential public health risks and would facilitate lake restoration for public use. The reduction of contaminant load in these sediments would minimize possible ingestion risk during recreational use of the lake. The cancer risk for arsenic via the ingestion exposure pathway would be reduced to approximately 1×10^{-5}.

However, sediments exceeding the target level concentration of 120 mg/kg would remain in the lake. Natural water dynamics, human disturbance of the sediments and the growth of vegetation may redistribute the remaining contaminated sediments. Any of these occurrences may result in previously clean areas exceeding the action level, or may result in previously contaminated areas becoming clean. Therefore a long-term monitoring plan would be required to measure the effectiveness of this alternative. Additional remedial activities may be required in the future if significant redistribution of contaminated sediment occurs resulting in a cancer risk level above the target of 1×10^{-5}. In addition, because this alternative would result in contaminated sediments remaining on-site (in the lake), CERCLA as amended would also require that the site be reviewed every five years to determine the effectiveness of the alternative or to identify new technologies that could be applied to the problems of this particular site.

No adverse environmental impacts are expected to result from the implementation of this alternative. As this alternative would remove contaminated sediments that underlie a 2.5 foot water column depth, dredging would occur in shallow water areas. The resuspension of sediments would be localized and temporary. The disturbance of fish, wildlife and biota would be minimal.

The fixated sediment would be transported and disposed of in a licensed off-site nonhazardous landfill facility. This facility would not be expected to pose public health risks or risks to the environment because it would be a fixed facility in compliance with all appropriate regulations and the mobility of the arsenic in the fixed sediments is low.

o <u>Reduction of Toxicity, Mobility or Volume</u>:
Immobilization is well suited for solidifying sediments containing heavy metals and other inorganics such as arsenic. This form of fixation is generally affected by the sediment matrix, contaminant constituents, and the fixation additives. Many of the commercially available processes use proprietary additives and claim to stabilize a broad range of compounds from divalent metals to organic wastes. Some research results (USEPA, 1985b) indicated that a successful fixation of arsenic-contaminated sediment could be obtained by utilizing a modified process that involved the use of sodium silicates.

Sediment chemical fixation has been designed based on the results of bench-scale treatability tests including three different additive formulations (see Union Lake RI Report Section 6.0). The treatability test results indicated that samples consisting of sediments, K-20/LSC, activated carbon, Portland cement and fly ash might meet the performance criteria. After 48 hours of curing, the mixture yielded RCRA EP Toxicity Test results of approximately 1 mg/l of leachable arsenic. The fixated sample would have approximately 9,000 lb/ft^2 of Unconfined Compressive Strength (UCS), which is much higher than the 1,500 lb/ft^2 generally required for landfilling to support truck traffic and other earth-moving equipment. In addition, the sample yielded USEPA Multiple Extraction Procedure (MEP) results with a maximum arsenic leachate concentration of 0.32 mg/l. The MEP is used to estimate the long-term stability of the treated material under conditions simulating 1,000 years of exposure to acid rain (48 CFR 52686-87, November 22, 1982). Based on these test results, as well as the discussion presented in Section 3.1.1.2.2, it is assumed that the fixation process could be optimized such that the fixed sediments are delistable.

K-20/LSC is an inorganic silicate-based material, which has the following major functions contributing to successful fixation:

- Precipitation of inorganic arsenic
- Encapsulation of arsenic contaminants

- Protection and stabilization of encapsulated arsenic contaminants

- Activated carbon powder adsorption of organic arsenic in a fixated matrix

Based on the MEP test data, the treatment processes used for this alternative would be irreversible, and arsenic bound in the sediment would not be expected to be leachable. Thus chemical fixation would provide an almost permanent remedy by reducing total mobility of both inorganic and organic arsenic in the contaminated sediments that are treated. The off-site nonhazardous landfilling of the fixated sediments would also provide an adequate containment for reducing the mobility of contaminants, but would not contribute to overall reduction in the toxicity or volume of the contaminants. This alternative would greatly reduce the mobility of arsenic sediments that pose threats to human health. The toxicity of Union Lake water in the areas of concern may be reduced as a consequence of this alternative; suspension of contaminated solids and phase transfer of soluble arsenic may be reduced.

Implementability:

- Technical Feasibility: This alternative involves on-site hydraulic dredging, chemical fixation and off-site nonhazardous landfilling, which are all well-developed and proven technologies and are all commercially available. Hydraulic dredging for shallow water sediment removal, using equipment such as a Mud Cat, can be provided by many vendors and is readily available for lease or purchase.

  Chemical fixation technologies are commercialized and provided by many manufacturers with their own proprietary blends. The commercial silicate blend used for the treatability study was selected because of its ability to be custom-blended as needed for a particular application. Similar blends are available from other vendors if the necessity arises. Other materials required for chemical fixation, such as Portland cement, fly ash, and activated carbon powder, are all common industrial materials commercially available. The equipment required for chemical fixation includes standard cement mixing and handling facilities, which are also commercially available.

  The physical-chemical precipitation systems for the supernatant treatment are traditional industrial wastewater treatment processes which can be installed with off-the-shelf hardwares. Nonhazardous landfill facilities are available within a reasonable distance from the site.

Hydraulic dredging can easily be performed to depths below the expected limit of contamination (one foot). On-site sediment and water testing would be required to monitor the Mud Cat's effectiveness. One pass of the Mud Cat over an area can remove approximately 1.5 feet of sediment. If necessary, a second pass over the same area could be performed to meet a specified cleanup level. The chemical fixation process utilizing the conventional cement mixing and blending equipment could handle many variations in sediment composition. The solidification/fixation/stabilization of sediments to achieve an arsenic leachate concentration below the target level of 0.32 mg/l would be simple from a technical standpoint; increasing additive dosage rates to obtain the target level would have little effect upon the treatment system components. There are no appreciable construction or operation difficulties anticipated for the fixation system. Similarily, the construction and operation of the supernatant water treatment system is not expected to encounter any unknown problems.

The chemical fixation process provides a reliable method for meeting all performance goals. It would be unlikely that any technical difficulties would lead to schedule delays. Labor and materials are readily available for all components of this alternative. The relatively complex components of this alternative are sediment and water treatment; however, these are proven technologies. The other components are comparatively simple.

Conditions external to the site, such as equipment and disposal facility availability, present no known problems at this time. The reliability of this remedial alternative would be high.

The time required for implementation of this remedial alternative is approximately 24 months. If the need arises to treat more sediments than anticipated, this could be accomplished by extending the remediation period. The time to achieve beneficial results (i.e., to reuse the lake for recreational purpose) would be almost immediately following the completion of the construction.

- <u>Administrative Feasibility</u>: Treated supernatant from the thickening process would be returned to Union Lake. Since this is an on-site Superfund discharge, a discharge permit would not be required; however, a statement that this discharge would be in compliance with ARARs would be required for state and local approvals. Since the supernatant would be treated to meet the Safe Drinking Water Standards and New Jersey Surface Water Quality Standards, the state and local approvals for discharge to the lake should not pose a problem.

Institutional administration would be required to locate a nearby nonhazardous landfill site that could accept the fixated sediments. Since the waste would be disposed of off-site, EPA headquarters would be responsible for approving the delisting for petition. This may be a relatively lengthy process. Based on the results of the treatability study with confirmation from the vendor, and with concurrence from EPA Region II, the fixed sediment is expected to be delistable; therefore, disposal at a nonhazardous landfill would not be expected to present any problems. In addition, coordination with the local traffic authorities would be required to control the additional traffic for transporting the treated solids. An appropriate local traffic control plan would be implemented by the local authorities.

- <u>Cost</u>: The capital cost for this alternative, as outlined in Table B-2, is estimated at $79,062,000. Operation and maintenance costs for this alternative, outlined in Table 3-9, are approximately $13,000 a year, for 30 years. The present worth, valued at $79,304,000, represents all of the activities to dredge, thicken, fixate, haul, and landfill sediments; perform all operation and maintenance functions on the treatment system components; perform annual monitoring to assess sediment redistribution; and perform the six required five-year reviews.

  In the event that the treated soils cannot be considered delistable, off-site associated RCRA landfilling would be required. The present worth of the treated soils in a RCRA landfill is estimated at $113,830,000.

- <u>Compliance with ARARs</u>

  The Rivers and Harbours Action Section 10 regulation requires that adequate preventive measures be provided to minimize disturbance to lacustrine areas. Hydraulic dredging activities in the lake would require appropriate preventive measures to minimize resuspension, erosion, and dissolved oxygen depletion.

  The lacustrine areas would be within the broader "waters of the U.S." jurisdiction of Section 401 and Section 404 of the Clean Water Act (CWA). Section 401 of the CWA requires that any activity must not result in a discharge that violates water quality criteria based on existing water quality and water body classifications.

Section 404 requires that no remedial alternative affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. Coordination with state and federal agencies would be necessary to obtain the 401 and 404 permits, and to obtain water quality certifications to comply with these ARARs.

As required by the federal and state location-specific ARARs, any remediation activity (e.g., dredging) performed in wetlands, flood plains or coastal areas would be performed to mitigate adverse impacts on sensitive areas. Dredging of contaminated sediment, which by itself fulfills the goals of these regulations, would be limited to the extent necessary to achieve the cleanup objective. The Contractor would avoid wetlands and flood plains during the implementation of the remedial actions to prevent degradation of these areas. Other examples of control measures that would be taken include erosion control, flow restoration and treatment of discharges.

The Fish and and Wildlife Coordination Act requires that the appropriate agency exercising jurisdiction over a wildlife resource, and the U.S. Fish and Wildlife Service, be consulted before undertaking any action that modifies a body of water. Special attention must be given to the impact on wetland and floodplains (lake shores) in accordance with Executive Orders 11990 and 11888. In addition, the National Endangered Species Act requires that special attention be given to the impact on areas where endangered species reside.

The dredged sediments would be chemically fixated on-site. The requirements for the treatment activities are that the facilities would be constructed, operated and maintained according to RCRA facility standards, and according to OSHA Industry Standards and Regulations concerning hazardous wastes. RCRA 40 CFR 264 is applicable for these activities.

RCRA 40 CFR 261.2(c)(1) and (d)(1) govern the degree of treatment applicable in regulating particulate air emissions from handling and transporting the fixated material for off-site disposal. Dust suppression measures would be provided for any potential fugitive dust pollution.

The supernatant waste stream would be treated and discharged in compliance with the effluent requirements of the National Pollutant Discharge Elimination System (NPDES) and New Jersey State SPDES permit (NJAC 7:14A.2), as well as the New Jersey Surface Water Quality Standards.

The treated sediments would be transported off-site according to Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste (40 CFR 263 and N.J.A.C. 7:26-3 and 7).

As discussed in Section 1.1.2.2, it is assumed that the fixated material is delistable, and thus no longer subject to RCRA LDRs.

Since arsenic-contaminated sediments would remain in the lake, CERCLA as amended would require that the site be reviewed every five years to determine the effectiveness of the alternative, or to identify new technologies that could be applied to the problems at this particular site.

Based on the above analysis, it is expected that Alternative 2A would comply with the ARARs identified.

- o <u>Overall Protection of Human Health and the Environment</u>

This alternative involves the removal and treatment of those sediments that were identified as a potential public health risk. Removal of these sediments would reduce the cancer risk level via the sediment ingestion exposure pathways to 1×10^{-5} or lower.

Chemical fixation processes produce a solidified and stabilized matrix which is believed to be nonhazardous, and thus delistable. Chemical fixation would be a permanent and irreversible remedy for the contaminated sediments. It completely reduces the mobility of the arsenic compounds in the sediments.

The remaining arsenic-contaminated sediments in the lake could pose a public health threat if the sediments are redistributed, by natural transport mechanisms or human disturbance, to areas underlying a water column depth of less than 2.5 feet. These sediments would be accessible for human ingestion.

Only a small percentage of arsenic (less than 5%) would be removed from the lake as a result of this alternative. Further reduction in the arsenic in the lake sediments, if desired, would have to be accomplished by natural processes. Due to the limitations of the available data, the mechanics of the lake are not fully known. There are two pathways for arsenic in the sediments to be removed by natural processes: arsenic desorption into the lake water and suspension of the arsenic-contaminated sediment into the lake water. In both of these pathways the arsenic could be transported out of the lake in the overflow. However, the arsenic desorption rate cannot be quantified utilizing the existing data. Furthermore, sediment transport/redeposition patterns within the lake are unknown. Therefore, while this alternative is protective of human health, the reduction of potential adverse environmental impacts as a result of this alternative cannot be quantified. It is believed that the implementation of this alternative may improve the lake ecosystem by reducing the potential exposure pathways of the arsenic contamination to the fish and wildlife.

- <u>State Acceptance</u>

  No state comments have been received to date.

- <u>Community Acceptance</u>

  No public comments have been received to date.

4.2.3 Alternative 2B - Dredging/Thickening/Fixation/On-Site Nonhazardous Landfill

4.2.3.1 Description

The major features of this alternative, depicted in Figure 4-1, include hydraulic dredging and chemical fixation of contaminated sediments, supernatant treatment and discharge, and on-site nonhazardous landfilling of the treated sediments. This is a source control (removal and treatment) alternative, which is exactly the same as Alternative 2A except that the fixated sediments would be disposed of on-site. The hydraulic dredging, thickening, chemical fixation, and supernatant water treatment systems would be the same as those discussed in Alternative 2A.

- <u>On-Site Nonhazardous Disposal</u>

  The fixated sediment would be transported by trucks from the curing area to a landfill constructed on-site and disposed of there. The landfill would be situated in the southern section of the ViChem plant site. The ability to place the landfill on ViChem property has been facilitated by EPA's definition of Union Lake as being part of the "Superfund Site".

The land area required for the landfill would be approximately 10 acres. Some of the area would be used for roads and maintenance facilities. The landfill would be constructed in accordance with the New Jersey Solid Waste Regulations (NJAC 7:26) requirements for nonhazardous sanitary landfills. The on-site landfill facility would contain a low permeability base and liner system, a leachate collection system and a three-layer capping system.

Two feet of clay, with a permeability less than 10^{-7} cm/sec, would be used as the landfill base. A synthetic liner of 460 mil high density polyethylene (HDPE) would be placed over the clay bed. The leachate collection system would consist of a two foot thick sand layer and a six-inch piping network, which would be groups of perforated drainage pipe headed and backfilled with a gravel envelope. Layouts would include a base liner slope of two percent and pipe grades of 0.005 feet at a spacing of 100 feet. The leachate would be collected in a sump and trucked to a nearby sewage industrial treatment plant for disposal.

The treated sediments would be deposited, graded, and compacted. After the completion of waste deposition, a three-layer capping system would be installed. The capping system would consist of a clay layer, a drainage layer and a vegetation layer. The sand layer and clay layers would prevent a bathtub effect and the surface infiltration of water, while the vegetation layer would provide erosion control for surface runoff. The two-foot clay layer would be placed directly on the site surface and would have a permeability of 10^{-7} cm/sec or less. A one-foot sand layer would be installed as a drainage layer and have a permeability greater than 1×10^{-3} cm/sec. Two feet of seeded topsoil would be placed on top of the sand layer to prevent erosion. As indicated in Alternative 2A, the total fixated sediment volume to be disposed of would be approximately 116,000 cubic yards.

A long-term, 30-year post closure groundwater monitoring program would be required to detect any leaching of contaminants from the fixated sediments. The groundwater monitoring system would include at least four monitoring wells, one upgradient and three downgradient of the landfill.

The major facilities and construction components for the on-site landfill are summarized in Table A-3 of Appendix A.

4.2.3.2 Assessment

- Short-Term Effectiveness: The short-term effectiveness of hydraulic dredging and on-site chemical fixation would be identical to that presented for Alternative 2A described in Section 4.2.2.2. This alternative differs from Alternative 2A in that the fixated sediments would be disposed of in an on-site nonhazardous landfill facility. During the construction of the landfill, workers would be properly protected against dermal contact and inhaling dust which would be generated during remedial action activities. The landfill activities would require local transportation and disposal, therefore traffic associated adverse impacts on the environment are small. The nonhazardous landfill would be located at the ViChem plant site. This area is not a sensitive ecosystem area such as a wetland area. On-site landfilling of treated sediments would pose little risk to groundwater and surface water qualities due to the low mobility of the fixated sediments and the effectiveness of the landfill system.

  The time of completion is estimated to be two years. The short-term effects during the implementation can be minimized by utilizing appropriate protection and control measures.

- Long-Term Effectiveness: As with Alternative 2A, the removal and treatment of those arsenic-contaminated sediments identified as public health risks would reduce the baseline human health risks associated with ingestion of the arsenic sediments. A substantial quantity of arsenic would remain in the lake, which could be redistributed to the clean areas. Long-term monitoring would be required to measure the effective- ness of this alternative. Alternative 2B differs from Alternative 2A in that it utilizes a nonhazardous landfill constructed on-site for the disposal of fixated sediments. The main benefits associated with this alterative are avoidance of the lengthy transportation to the off-site landfill facility and associated costs.

  As discussed in Section 3.1.1.2.2, the fixated sediments would be expected to be delistable. Such materials, even if disposed of in an unlined and uncapped landfill, would pose a very low threat of groundwater contamination.

  The landfill design consists of an impermeable base, synthetic liner, a cap, and a runoff collection and drainage system to meet the New Jersey Sanitary Landfill requirements. This design is intended to assure that virtually no leachate would penetrate into the groundwater.

The combination of chemical fixation and a lining would provide double protection against contaminant migration.

The proposed landfill site on the ViChem plant site is not located in an environmentally sensitive area. On-site landfilling of the fixated sediments would pose little risk to groundwater or surface water quality due to the low mobility of the fixated sediments and the effectiveness of the landfill system. A long-term management plan would be required to monitor the effectiveness of the landfill. In addition, institu- tional controls would be required to ensure that future uses of the area would not jeopardize the integrity of the landfill.

o <u>Reduction of Toxicity, Mobility, or Volume</u>: Alternative 2B entails hydraulic dredging and chemical fixation, which would result in the same significant reduction of mobility of arsenic from the dredged contaminated sediments as discussed in Alternative 2A. Chemical fixation processes do not detoxify directly, but serve to trap contaminants in a matrix. The chemical fixation process would result in an increase in the volume and weight of contaminated material to be disposed.

As previously stated, this alternative differs from Alternative 2A described in Section 4.2.2 only in that fixated sediments would be disposed of on-site in a nonhazardous landfill. The disposal of fixated sediment in a nonhazardous landfill would further reduce the mobility of contaminants through containment. The combination of fixation/solidification and a lining system in a landfill would provide double protection against the leaching of contaminants into groundwater. A properly designed on-site or off-site nonhazardous landfill would have the same effectiveness in terms of reduction in toxicity, mobility or volume of the waste.

<u>Implementability</u>

o <u>Technical Feasibility</u> - As discussed in Alternative 2A, fixation of soil is a well-established process, particularly for inorganic contaminants, and is very reliable, as proven through bench-scale testing. The fixated product would be an impermeable mass with structural stability that could withstand wet-dry and freeze-thaw weather conditions. Under this alternative, the landfill would effectively contain the wastes, as long as it is properly constructed and regularly maintained.

The primary limiting factor regarding the implementation of this alternative would be the delisting of the treated sediment. Treatability results and discussions with the fixation vendor have indicated that treating sediments to obtain EP Toxicity leachate arsenic concentrations below 0.32 mg/l would be technically feasible. Upon meeting this goal, a substantive tool for delisting could be presented to EPA Region II for approval.

For an on-site landfill, the availability of land should not pose a significant problem. The construction of a nonhazardous landfill would not be expected to be complex, but would require a substantial on-site construction effort with conventional heavy equipment. It would not pose a constructibility or technology problem.

The time to complete remediation would be approximately 24 months. Beneficial results would be achieved following dredging and treatment of sediments. Contractors and equipment would be readily available. The time required to construct the landfill would take approximately six months. The drawbacks would be that the lifetime of the synthetic liners would be uncertain, and that replacement of liners, if necessary, would be difficult.

- Administrative Feasibility: Since the landfill would be located on-site, a formal delisting petition to EPA Headquarters would not be necessary. Rather, the Regional Administrator in EPA's Region II could authorize nonhazardous disposal. The Regional Administrator may have to provide to EPA Headquarters personnel information supporting the decision to dispose of the treated sediments as nonhazardous waste rather than as hazardous waste.

  On-site landfilling of fixated sediments would require appreciable administrative efforts to coordinate with state and local agencies to negotiate and secure an agreement on land acquisition. The ViChem plant site is in a partly residential area, therefore there may be considerable administrative effort to obtain local public approval of siting a landfill there. Implementability of an on-site nonhazardous landfill would entail efforts to ensure proper design and construction. Long-term administrative management would be necessary to monitor the landfill and underlying groundwater source, as well as perform five-year reviews. To ensure adequate containment of wastes, long-term maintenance would also be required.

- Cost: The capital cost for this alternative, as outlined in Table B-3, is estimated at $57,811,500. Operation and maintenance costs, outlined in Table B-10, are approximately $92,700. The present worth, calculated at a rate of 5%, is $59,122,000. This cost represents all of the activities to dredge, thicken, fixate, haul, and landfill sediments; construct a landfill and perform all operation and maintenance functions on the treatment system components and the landfill; perform the annual sampling in Union Lake; and perform the six required five-year reviews.

In the event that the treated soils cannot be considered delistable, on-site RCRA landfilling would be required. The present worth associated with disposal of the treated soils in a RCRA landfill is estimated at $59,273,000.

- <u>Compliance with ARARs</u>: The same ARARs that apply to the hydraulic dredging, chemical fixation and supernatant treatment/discharge activities discussed for Alternative 2A are applicable for this alternative. Chemical fixation of the sediments would sufficiently immobilize the arsenic so that the treated material could be delistable and disposed of in a nonhazardous landfill, thus waiving the requirements of RCRA LDRs. The New Jersey Solid Waste Regulations (NJAC 7:26) Subchapter 2A - Additional Specific Disposal Regulation for Sanitary Landfill (May 5, 1986) were used to base the design of the on-site nonhazardous landfill facility. The on-site nonhazardous landfill facility would consist of a liner system, a leachate collection and treatment system, a surface drainage system and erosion control, and a surface capping system in accordance with the requirements of Subchapter 7:26-2A-4 General Prohibitions and Requirements. These regulatory requirements and standards were established for the design and construction of landfills to ensure that adverse impacts are minimized and controlled, and the pollution of the environment is prevented.

  Based on this analysis, Alternative 2B would be expected to comply with all ARARs identified.

- <u>Overall Protection of Human Health and the Environment</u>

  The evaluation of overall protection of human health and the environment discussed in Alternative 2A is applicable for this alternative, except that the treated sediments would be disposed of in an on-site nonhazardous landfill. As discussed in Alternative 2A, the immediate public health risk would be reduced to the target level of 10^{-5}. Contaminated sediments would remain on-site and future redeposition of these sediments to areas where human ingestion could be possible (within the two and one half foot water depth) could cause the future cancer risk to exceed the target. The chemical fixation treatment of the contaminated sediments would immobilize arsenic compounds leaching from the sediments to minimize further exposure to human receptors and the environment.

This alternative would dispose of the treated sediments in an on-site nonhazardous landfill facility that would be constructed at the ViChem plant site. The proposed site is not in a sensitive ecosystem area. The fixated sediment would be nonhazardous and its disposal in an on-site landfill facility would pose very little risk to groundwater and surface water quality. Even if such materials were disposed of in unlined and uncapped landfills, the threat of groundwater and surface water contamination would be considered relatively low. This is largely due to the low mobility of fixated sediments and the effectiveness of the landfill facility.

- <u>State Acceptance</u>: No state comments have been received to date.

- <u>Community Acceptance</u>: No public comments have been received to date. However, it should be noted that the ViChem plant is located in a partly residential area, and community acceptance of a landfill at the site may be questioned.

4.2.4 Alternative 3A - Dredging/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

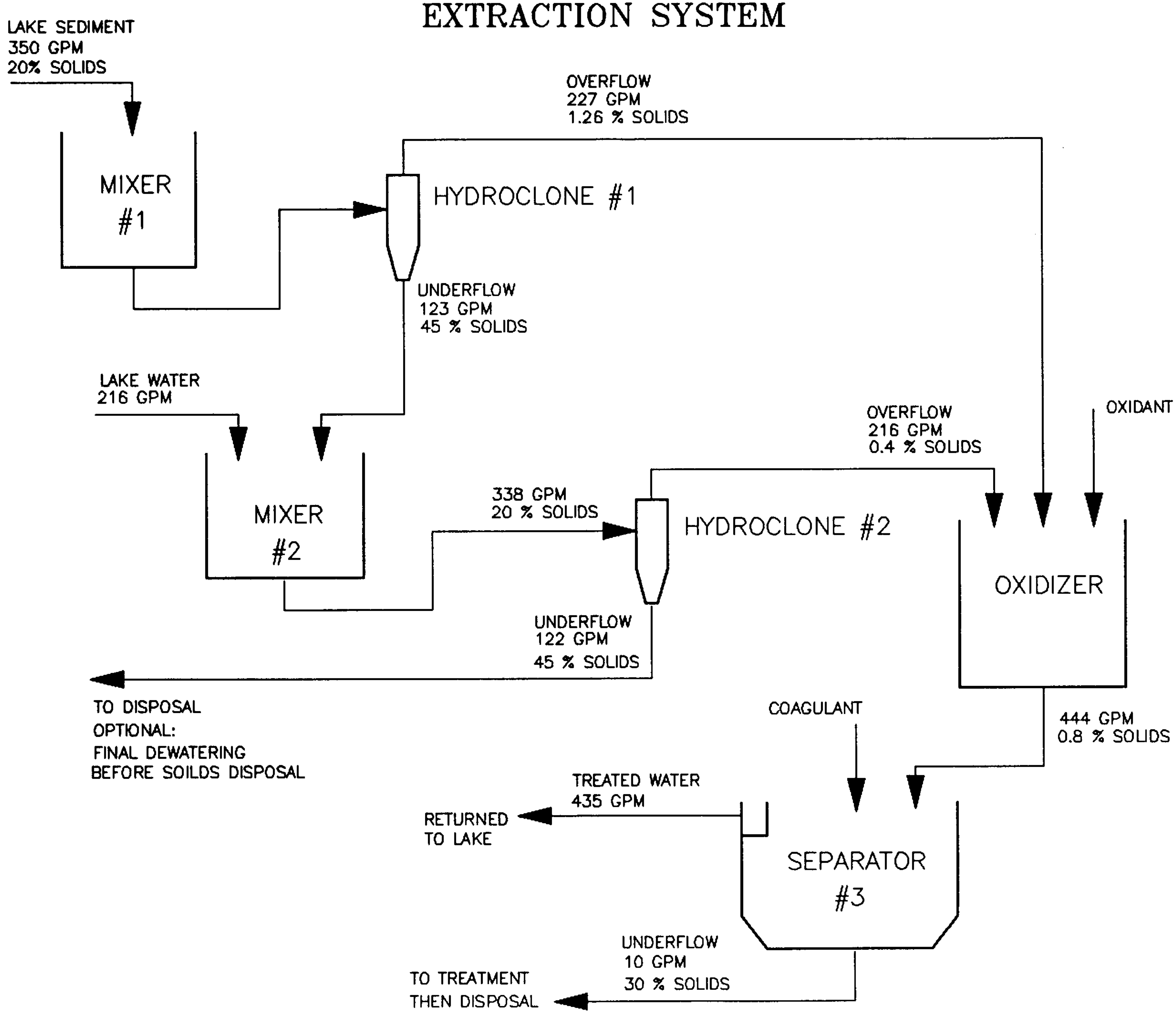
4.2.4.1 Description

The major features of this alternative include hydraulic dredging of contaminated sediment, sediment water extraction treatment and disposal, supernatant water treatment and discharge, and hazardous sludge disposal. A water extraction process and associated wastewater treatment system would be utilized to remove the arsenic from the sediments. A schematic flow diagram is shown in Figure 4-2. This is a source control (removal/treatment) alternative in which the contaminated sediments would be removed and the arsenic would be extracted from the sediments. The highly contaminated arsenic sludge generated by the extraction process would be treated and disposed of by a vendor at an off-site RCRA hazardous waste facility. The processed sediments would be disposed of in an off-site nonhazardous landfill facility as discussed in Alternative 2A.

- <u>Sediment Water Extraction and Wastewater Treatment</u>

  The in-place sediment is approximately 54% solids. The dredging operation would draw lake water into the sediment so that a slurry of approximately 20% solids would be pumped into a mixing vessel (actually 2 mixers in parallel) with a 2-hour retention time. A separate feed line of lake water, operating on density control, would add water to the mixer so that the maximum solids concentration would not

FIGURE 4-2
EXTRACTION SYSTEM



exceed 20%. The slurry would be pumped to a bank of 14 six-inch-diameter hydroclones mounted in parallel. Seven hydroclones would be operating and seven would be standby units. An underflow of 45% solids would discharge into a second mixer (actually two mixers in parallel); the overflow would go to a supernatant water treatment system. Lake water would be pumped into the second set of mixers, under density control, to maintain a slurry of 20% solids. The slurry would then be pumped to a second bank of 14 hydroclones (seven operating and seven standby). The residual arsenic in the underflow solids would be a maximum of 10% of the original amount of arsenic present in the sediment. The underflow would then go to final dewatering as described in Alternative 2A. The dewatered sediment would then be sent to an off-site nonhazardous landfill.

The overflow from the second bank of hydroclones would go to the same supernatant water treatment system as the overflow from the first bank of hydroclones.

The overflow streams from the hydroclones would be discharged to a reactor tank. Any soluble arsenic would be in the form of As_2O_3, which is soluble in water. The As_2O_3 would be oxidized with potassium permanganate to As_2O_5, which is insoluble in water and would precipitate out of solution. The reaction is:

$$5\ As_2O_3 + 4\ MnO_4^- + 12H^+ - 5\ As_2O_5 + 4\ Mn^{++} + 6\ H_2O$$

The reaction requires a low pH of 2.0, therefore hydrochloric acid would be added ahead of the permanganate.

The liquid solids mixture would flow to a coagulator-clarifier, where the liquid pH would be raised to 6.5 with the addition of sodium hydroxide (NaOH) or lime ($Ca(OH)_2$). Ferric chloride ($FeCl_3$) would be added to coagulate the arsenate and manganate precipitate into larger and denser particles to facilitate settling. A liquid polymer would also be added to aid in the flocculation of the large particles.

The overflow water from the clarifier would be discharged back to the lake. A portion of the water would be used as a wash water later in the chemical extraction process.

o <u>Off-Site Hazardous Sludge Disposal</u>

Sludges generated from the coagulator-clarifier would contain settled solids, metallic and organic arsenic, and other residues from the treatment process in a concentrated form. Sludges would be hauled off-site by a licensed vendor to a disposal facility where treatment could incorporate any number of viable technologies (for the purpose of this report, it is assumed that fixation would be used). Landfilling would take place once land disposal standards are obtained from the treatment process (assumed to be a treatability variance of 1 mg/l arsenic in the EP Toxicity extract from the treated sludge).

The major construction components and facilities for this alternative are outlined in Table A-4 of Appendix A.

4.2.4.2 Assessment

o <u>Short-Term Effectiveness</u> - The short-term effectiveness concerns with this extraction alternative include public health threats, the safety of workers during the implementation activities, and adverse impacts on the environment.

The risk to the community and to the workers generated during the excavation activities are similar to those discussed in Alternative 2A (Section 4.2.2.2). Adequate dust suppression measures and protection equipment for personnel would be provided to minimize the risks of inhalation and direct contact. The on-site risk to worker safety would be slightly higher for the extraction and extractant treatment than for the chemical fixation due to the greater number of treatment processes required for this alternative. The extractant treatment system would utilize liquid chemicals, which can be spilled easily. However, adequate preventative measures and proper personnel protective equipment would be provided to workers to prevent direct contact with wastes and chemicals. As stated in Alternative 2A, the short-term risks to workers would be minimal for this alternative.

This alternative would require adequate land space to lay out the treatment process. Potential worker safety and environmental threats would be associated with pipe leaks, spills or accidental releases of the extractant. These threats could be minimized by utilizing preventative measures and standardized industrial construction procedures.

The short-term impacts on the environment, such as traffic problems and associated noise and air pollution, for this alternative would be somewhat less than that presented in Alternative 2A. An appropriate local traffic control plan would be implemented to minimize these short-term environmental impacts.

The time of completion is estimated to be two years. Any short-term effects could be minimized by utilizing adequate preventative measures and proper personnel protection equipment.

- Long-Term Effectiveness - Extraction methods are designed to remove arsenic compounds from the contaminated sediments and thus attain reductions in the toxicity and mobility of the waste. The removal of the contaminated sediments would minimize public health threats. The treated sediments would contain total arsenic below the action level of 120 mg/kg and are not expected to leach arsenic above 0.32 mg/l (VHS model delisting criteria) and would be expected to be delistable. The extractant separated from the sediment would be treated to remove arsenic to below the target level of 0.05 mg/l prior to discharge. The extractant sludge is not expected to pass the 0.32 mg/l criteria for delisting, but is expected to pass the 1 mg/l treatability variance criteria, allowing for its disposal in a hazardous waste landfill. This alternative provides a permanent remedy for the contaminated sediments identified as a public health risk and off-site disposal of the treated wastes.

  As with Alternative 2A, the major benefits associated with this alternative would be the remediation of contaminated sediments using water washing. The cancer risks from arsenic via the exposure pathways of direct contact and the ingestion of sediment would be reduced to 1×10^{-5} target level. However, only approximately 5% of the arsenic would be removed from the lake. Long-term effects could be significant if the arsenic redistributes to the remediated areas due to natural transport mechanisms or human disturbance. If this occurs, additional remedial activities would be required. Therefore, a long-term monitoring program, estimated to be the same annual sampling and site visit inspection specified for Alternative 2A, would be required to measure the effectiveness of this alternative.

  The technology for this alternative would be expected to reduce the level of arsenic contamination in the sediments sufficiently to meet the hazardous waste delisting criteria. The treated sediments would be deposited in a nonhazardous landfill facility and the treated extractant discharged to Union Lake with minimal adverse impact to the environment.

- Reduction of Toxicity, Mobility, or Volume - The reduction of toxicity would be achieved by extracting the arsenic contaminants from the sediment by a washing process with water. Results from bench-scale treatability studies (see ViChem RI Chapter 6.0) indicated that extraction with water would meet the 120 mg/kg performance criteria established for the arsenic-laden sediment. It is assumed that the washed sediments would pass the EP Toxicity Leaching Criteria of 0.32 mg/l. Subsequent chemical oxidation and physiochemical precipitation would remove arsenic from the liquid extractant. The combination of both sediment and wastewater treatment would greatly reduce the toxicity and volume of the contaminant. Removal of arsenic from the sediments posing human health risks with subsequent off-site disposal of the sediment would greatly minimize the mobility of the contaminant.

Implementability

- Technical Feasibility - As stated in Alternative 2A, (Section 4.2.2.2) hydraulic dredging, excavation, supernatant water treatment and disposal of treated sediments in an off-site landfill facility are all well-developed technologies that are commercially available, highly feasible and reliable. Equipment necessary for implementing these technologies would also be readily available.

  The water extraction process would be a reliable technology and would meet the designated process efficiencies and performance goals. It would be unlikely that any unusual technical difficulties would arise. Labor and materials would be readily available for all components of this alternative. The relatively complex components of this alternative would be sediment and water treatment, which are currently proven technologies. The other components would be comparatively simple. There would be no major treatment difficulties that are expected during the implementation of this alternative, based on the following considerations:

  - Mud Cat dredges have been successfully used in various shallow water hydraulic dredging operations.

  - Water extraction is a conventional industrial process. Treatability studies demonstrated that water could extract arsenic from sediments to approximately 34 mg/kg.

  - EP Toxicity results for arsenic in untreated sediment samples yielded results below 0.32 mg/l, the target level for delisting treated wastes.

- o Chemical oxidation and coagulation/flocculation/precipitation with $FeCl_3$ are both traditional wastewater treatment technologies for removing arsenic and organics.

More than one vendor or manufacturer would be capable of providing a competitive bid for each component of this alternative. Several vendors would be able to supply turnkey services for disposal of the hazardous treatment sludges. It is estimated that approximately 36 months would be required to implement this alternative. This is considered to be the time to achieve beneficial results.

- o <u>Administrative Feasibility</u> - The treated sediments from the separation units and the treated extractant waste streams would be returned to Union Lake. A discharge permit would not be required since this would represent an on-site Superfund discharge. However, a demonstration that these discharges would be in compliance with ARARs would be required for State and local approvals. Since the supernatant would be treated to meet New Jersey Surface Water Quality Standards and NJPDES requirements, state and local approvals should not pose a problem. The treated extractant waste stream would contain total arsenic below the state's discharge limit (i.e., 0.05 mg/l).

  In order to operate and maintain this complex treatment system, an intensive operation and maintenance program would be required. Institutional administration would be required to secure a nearby nonhazardous landfill site for the disposal of the extracted sediments. Since the treated sediment is expected to be delisted by EPA headquarters as nonhazardous, it may be disposed of at a nonhazardous landfill. Delisting by EPA headquarters would require a formal petition and may require a long time to accomplish. Arranging for the transport and disposal of hazardous treatment sludges would require administrative effort. The growing number of licensed multiservice waste handling vendors should aid in the manageability of this remediation aspect. Annual site monitoring and five-year reviews demand long-term administrative attention. In addition, coordination with local traffic authorities would be required to control the additional traffic involved with transporting the treated sediments to the landfill. An appropriate local traffic control plan and air pollution control measures such as dust suppression would be implemented.

- Cost: The capital cost for this alternative as outlined in Table B-4, is estimated at $29,833,000. Operation and maintenance costs, outlined in Table B-11, are approximately $13,000 a year for 30 years. The present worth, valued at $30,075,700, represents all of the activities to dredge, extract with water, haul, and landfill nonhazardous sediments and hazardous treatment sludges; perform all operation and maintenance functions on the treatment system components; perform the annual monitoring in Union Lake; and perform the six required five-year reviews.

  In the event that the treated soils cannot be considered delistable, off-site RCRA landfilling would be required. The present worth associated with disposal of the treated soils in an off-site RCRA landfill is estimated at $47,470,000.

- Compliance with ARARs: The discussion on the compliance with ARARs in Alternative 2A in Section 4.2.2.2 is applicable for this alternative as well. The only items in Alternative 3A that differ from Alternative 2A is the off-site RCRA treatment and disposal of the arsenic-contaminated sludge generated from the extraction process and the additional effluent discharge to Union Lake generated from the extractant treatment system. The evaluation of Alternative 3A with respect to compliance with ARARs is summarized as follows:

  - Appropriate preventive measures would be provided to minimize resuspension, erosion and dissolved oxygen depletion during hydraulic dredging in order to comply with the requirements of the Federal Rivers and Harbors Act Section 10.

  - Hydraulic dredging would avoid the wetland areas where possible, and wetland restoration would be implemented for the disturbed areas in order to comply with Sections 401 and 404 of the CWA identified in Alterative 2A.

  - The extraction processes would be performed in order to convert the contaminated sediments into nonhazardous wastes in accordance with RCRA 40 CFR 261.2 requirements.

  - The installation and operation of the extraction system, the supernatant treatment system, and the extractant treatment system would comply with RCRA 40 CFR 264 Standards for Owners and Operators of Hazardous Waste Treatment Facilities.

- The supernatant waste stream and the extractant wastewater would be treated in compliance with the effluent requirements of Federal Clean Water Act Quality Criteria, New Jersey Surface Water Quality Standards and Clean Water Act NJPDES Discharge to Surface Water Requirements.

- The Clean Air Act and National Air Quality Standards would be complied with for particulate air emissions resulting from the handling and transporting of the extracted materials to an off-site disposal facility.

- DOT Rules for the Transportation of Hazardous Materials (40 CFR Parts 107, 171-1-171.500) would be complied with for transport of the arsenic-contaminated sludge to a RCRA treatment and disposal facility.

- Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste (40 CFR 263 and NJAC 7:26-3 and 7) would be complied with for the transport of the treated sediments to a nonhazardous landfill.

- Disposal of the delisted treated sediments at a nonhazardous landfill facility and treatment and disposal of the arsenic contaminated sludge at a RCRA facility would comply with RCRA LDRs.

- New Jersey Solid Waste Regulations (NJAC 7.26) would be used to verify that existing sanitary landfill facilities could dispose of the treated sediment safely.

  Based upon the above analyses and assumptions, Alternative 3A is expected to meet all applicable ARARs and TBCs.

<u>Overall Protection of Human Health and the Environment</u>: This alternative would have the same overall protection of human health and the environment as discussed in Alternative 2A. Removal of the contaminated sediments would achieve a reduction in the risks to public health due to sediment ingestion in the shallow areas of the lake where the sediment arsenic concentration exceeds 120 mg/kg. Extraction would remove arsenic compounds from the contaminated sediments and would result in a reduction of the toxicity of the sediments and the volume of contaminants in the sediments. Off-site disposal of the treated sediments and the sludge containing the arsenic would slightly reduce the volume of contaminants remaining on-site.

As with Alternative 2A, this removal and treatment alternative would reduce the existing cancer risk level in the shallow lake areas containing sediment arsenic concentrations greater than

120 mg/kg to a level of $1 \times 10_{-5}$ assuming the most plausible sediment exposure pathway model. After implementing this alternative, and after implementing a successful management of migration alternative for the groundwater at the ViChem facility, the public health risks from the lake areas would be reduced. Long-term monitoring would be required to assess the arsenic inventory in the lake and the redistribution pattern of the sediments.

As discussed in Alternative 2A, the reduction of potential adverse environmental impacts as a result of this alternative cannot be quantified due to the limited available data.

State Acceptance: No state comments have been received to date.

Community Acceptance: No public comments have been received to date.

4.2.5 Alternative 3B - Dredging/Extraction/Sediments to On-Site Nonhazardous Disposal/Off-Site Hazardous Sludge Disposal

4.2.5.1 Description

The major features of this alternative include hydraulic dredging of contaminated sediments; water extraction of the dewatered sediments, supernatant water treatment; extractant wastewater treatment and on-site non-hazardous landfilling of the treated sediments; and off-site hazardous disposal of treatment sludges. This is a source control (removal and treatment) alternative and is exactly the same as Alternative 3A, except that the treated sediments would be disposed of on-site in a nonhazardous landfill in a manner previously described in Section 4.2.3.1 for Alternative 2B. The only difference between the two landfills is the size; the volume of sediments from this alternative would occupy a volume of approximately 70,000 cubic yards and require six acres of land.

4.2.5.2 Assessment

o Short-Term Effectiveness: Short-term effectiveness for Alternative 3B is the same as for Alternative 3A (Section 4.2.4.1), except that in this alternative the extracted sediments would be disposed of in an on-site nonhazardous landfill facility. On-site workers would potentially be exposed to contaminants by dermal contact and by dust inhalation during hydraulic dredging, extraction and sediment transfer to the landfill facility. To minimize or prevent such exposure, dust control measures and protection equipment for personnel would be used. The treated sediment would be transported via truck to the on-site landfill at the ViChem plant site. The adverse impacts on the environment during the remedial alternative would be temporary and minimal. The time required to complete this remedial action and to achieve protection is approximately three years.

- Long-Term Effectiveness: Alternative 3B has the same long-term beneficial effectiveness as Alternative 3A. There are expected to be minimal adverse environmental impacts resulting from installing nonhazardous landfill at the ViChem plant site.

  An on-site nonhazardous landfill would require long-term administrative management, including facility maintenance and groundwater monitoring. A secondary waste management program may be required to handle the potential leachate from the remaining arsenic compounds in the treated wastes.

  As discussed in Alternative 3A, this alternative would remove and treat those sediments identified as a potential public health risk. This action would reduce the cancer risk level via the sediment ingestion exposure pathway to 1 x 10^{-5}. Long-term monitoring would be required to measure the effectiveness of this alternative and the redistribution patterns of the sediment in the lake.

- Reduction of Toxicity, Mobility and Volume: The removal and treatment of the contaminated sediments would reduce the existing arsenic loads from the lake areas that pose the greatest health risks and would also reduce slightly the potential migration of arsenic contaminants from sediments to surface water and regions downstream of Union Lake. The extraction process would extract arsenic from the contaminated sediments to below the target level of 120 mg/kg. Alternative 3B would result in a significant reduction in toxicity and volume of arsenic in the contaminated sediments by removing approximately 10 metric tons of arsenic from the lake areas. The mobility of the remaining arsenic in the treated sediments would be reduced because the sediments would be contained in landfill. Alternative 3B would yield the same results as Alternative 3A, except the nonhazardous landfill would be located on-site.

- Implementability

  Technical Feasibility: The technical feasibility of hydraulic dredging, excavation, extraction, supernatant water treatment and extractant wastewater treatment presented in Alternative 3A is identical to that of Alternative 3B. These technologies are considered highly feasible, reliable and are expected to be available. The implementation of this remedial alternative would require approximately 36 months for construction, operation and maintenance. There are no major treatment difficulties expected to occur during the implementation of this alternative.

  The construction of a nonhazardous landfill facility is a simple task that utilizes normal construction equipment. The only technical difficulty for the landfill facility maintenance would be the repair of the bottom synthetic liners. However, a well maintained capping system would minimize rainfall infiltration. This would prolong the useful lifetime of the synthetic membranes. The disposal of treatment sludges would be facilitated by a licensed vendor with treatment and landfill facilities available to him. As with Alternative 3A, the time to complete remediation and achieve beneficial results is 36 months.

Administrative Feasibility: As with Alternative 2B, an on-site landfill would require more administrative efforts than an off-site landfill. An on-site landfill would require the following institutional involvement:

- o Coordination with state and local governments and the owner of the ViChem property to negotiate and secure an agreement on land acquisition
- o Review, supervision and management to ensure proper design and construction of an on-site landfill facility
- o A long-term administrative management program for landfill maintenance, leachate collection and disposal, and groundwater monitoring

Additional administrative efforts would be required of the EPA Region II Regional Administrator to decide that nonhazardous disposal of the extracted sediments is acceptable. However, it would not be necessary to file a formal delisting petition to EPA Headquarters, which would ease administrative efforts somewhat. Five-year reviews of the landfill and annual reviews of the lake would be required. These institutional requirements are considered to be feasible.

- o Cost: The capital cost for this alternative, as outlined in Table B-5, is estimated at $19,798,500. Operation and maintenance costs, outlined in Table B-11, are approximately $59,100. The present worth, calculated at a rate of 5%, is $20,650,000. This cost represents all of the activities to dredge, extract with water, haul, and landfill nonhazardous sediments and hazardous treatment sludges; construct a nonhazardous landfill and perform all operation and maintenance functions on the treatment system components and the landfill; and perform the six required five-year reviews.

  In the event that the treated sediments cannot be considered delistable, an on-site RCRA landfilling would be required. The present worth associated with disposal of treated soils on an on-site RCRA landfill is estimated at $20,750,000.

- o Compliance with ARARs: Alternative 3B would comply with those ARARs discussed in Alternative 3A. In addition, the New Jersey Solid Waste Regulations (NJAC 7:26) Chapter 2A -

Additional Specific Disposal Regulation for Sanitary Landfill, would be used as the basis for the design, operation, closure, and monitoring plans of the on-site nonhazardous landfill. Based on this analysis, Alternative 3B is expected to comply with all ARARs identified.

- Overall Protection of Human Health and the Environment: Alternative 3B would provide the same overall protection of human health and the environment discussed in Alternative 3A, Section 4.2.4.2. The beneficial impacts would include reducing the sediment ingestion -related cancer risk level in the lake to 1×10^{-5}, assuming the most plausible sediment exposure pathway models. Long-term monitoring would be required to survey the redistribution patterns in the lake.

  The implementation of this alternative may improve the lacustrine ecosystem by reducing the potential exposure pathways of the arsenic contaminants to the fish and wildlife.

This alternative would dispose of the treated sediments in a nonhazardous landfill facility built at the ViChem plant site. The landfill components, such as the capping system and the lining system, would further protect human health and the environment by minimizing leachate generation and fugitive dust dispersion. This alternative would provide adequate protection to public health and the environment and it would somewhat reduce the existing toxicity, mobility and volume of arsenic contaminants in the lake sediments.

State Acceptance: No state comments have been received to date.

Community Acceptance: No public comments have been received to date. However, it should be noted that the ViChem plant site is located in a partly residential area. Local residents may be concerned about a landfill being built at the plant site.

4.2.6 Alternative 3C - Dredging/Extraction/Deep Lake Deposition of Sediments/Off-Site Hazardous Sludge Disposal

4.2.6.1 Description

The major features of this alternative include hydraulic dredging of contaminated sediments, water extraction of the dewatered sediments, supernatant water treatment, extractant wastewater treatment with discharge to Union Lake, uniform deposition of treated sediments in deep areas of Union Lake, and off-site hazardous disposal of treatment sludges. This is a source control (removal and treatment) alternative and is exactly the same as Alternatives 3A and 3B except that the treated sediments would be disposed of in deep sections of Union Lake.

- Deep Lake Deposition

  The treated sediments would be transported by barges equipped with pneumatic pumps to deep areas of Union Lake. The sediments would be pumped into the lake and allowed to settle uniformly over the lake bottom.

4.2.6.2 Assessment

- Short-Term Effectiveness: The short-term effectiveness for extraction of the arsenic is similar to that presented in Alternative 3A. This alternative differs from Alternative 3A in that the extracted sediment would be transported by a barge equipped with a pneumatic pump for dry solids to a deep area of Union Lake and disposed of. Dust suppression methods would be required when transferring the sediment to the barge and when discharging the sediment via pneumatic pump to the lake. On-site workers would be properly protected with personal protective equipment. As the lake is closed for recreational boating and there is no industrial shipping on the lake, the barge traffic would not have an adverse impact. There would be no appreciable truck-related effects and the traffic associated adverse impacts on the environment would be minimal.

  Potential short-term environmental impacts could occur as a result of the implementation of this alternative. Discharge of the extracted material may cause temporary resuspension of contaminated sediments. The resuspension would be localized and if deemed necessary, could be controlled through the use of silt curtains. The treated material would be discharged uniformly over a deep area to prevent any mounding of the material. Fish, wildlife and biota could be impacted during the discharge, however this would be temporary.

  The time required to complete this remedial action and to achieve protection is approximately three years.

- Long-Term Effectiveness: Alternative 3C has the same long-term beneficial effectiveness as Alternative 3A, except that there may be potential adverse environmental impacts resulting from deep lake deposition of the treated sediments. The treated sediments would be delistable, and thus by definition the potential for arsenic leachate is minimal. The extracted material would be discharged uniformly over deep areas of the lake to prevent mounding, which could potentially alter the natural channel flow of the lake and impact boating activities. The adverse environmental impacts would be minimal.

  As discussed in Alternative 3A, this alternative would remove and treat sediments identified as a potential public health risk. The cancer risk associated with sediment ingestion would be reduced to 1 x 10^{-5} or less. Thus this alternative would be protective of human health.

Long-term monitoring would be required to measure the effectiveness of this alternative and to monitor the redistribution patterns of the sediment. As discussed previously, the contaminated sediments with an arsenic concentration greater than 120 mg/kg remaining in the lake could potentially redistribute into areas where sediment ingestion could become a feasible exposure pathway (in water depths less than two and one half feet). Additional remedial actions would be necessary if this occurs. As contaminated sediments are remaining on-site, CERCLA, as amended, would require a review of the site every five years.

o <u>Reduction of Toxicity, Mobility, and Volume</u>: Hydraulic dredging of sediments identified as being detrimental to human health would reduce the toxicity, mobility, and volume of contaminants in Union Lake. Water extraction would desorb arsenic from sediments while chemical precipitation would remove soluble forms of arsenic from water. Treated wastewater discharge to the lake and deposition of treated sediments would not account for the addition of any mobile toxic contaminants to the ecosystem. The volume of arsenic contaminants in sensitive health risk areas would be reduced to acceptable standards. The mobility of arsenic in those areas would be reduced, as there would no longer be a source for contaminant suspension or migration once the sediments are removed.

This alternative would essentially offer the same reduction of toxicity and volume as the other two extraction alternatives; however, the lack of a controlled landfill to monitor the mobility of contaminants would be inherent with its implementation, thus placing it at a slight disadvantage to the other two alternatives. Recognizing the fact that deposition would not be achievable without first treating the sediments to low, acceptable leaching levels, this alternative has similar advantages that landfilling might offer. In addition, deposition of treated sediments in deep lake areas with high sediment arsenic concentrations, assuming that they exist, may increase the reduction of contaminant mobility offered by this alternative. Treated sediments could be deposited over sediments suspected of having high contaminant concentrations and might serve as a barrier to contaminant suspension and migration in the deeper areas of the lake.

o <u>Implementability</u>

<u>Technical Feasibility</u>: As previously discussed, the technologies to dredge, water wash, physically and

chemically treat the Union Lake sediments and water are highly feasible, available, and reliable. The availability and reliability of barges and pneumatic pumps to deposit treated sediments in the deep areas of the lake is considered to be equally as high. Numerous licensed vendors experienced in sludge disposal can be obtained to haul, treat, and landfill concentrated treatment residues.

The overall technical feasibility of this alternative is considered to be high. The lack of sophisticated monitoring equipment to track deposited sediment movement over the course of time places this alternative at a slight disadvantage to the alternatives with landfilling options. Considering the fact that the deposited sediments would contain arsenic concentrations within regulated leaching limits, this disadvantage becomes inconsequential. As with the other extraction alternatives, the time to complete remediation and obtain beneficial results would be 36 months.

Administrative Feasibility: Administrative concerns for this alternative would initially be most concentrated upon obtaining clearance for treated wastewater discharge and treated sediment deposition into Union Lake; long-term concerns would be focused upon periodic monitoring programs and five-year reviews. Additional concerns would arise from the off-site hazardous disposal of treatment sludges, which as stated in the previous extraction alternatives would be viable from an administrative viewpoint.

The discharge of treated wastewater would not require a permit, since it would take place on a Superfund site. As long as the discharge meets all ARARs, state and local approval should be obtainable. Treated sediments would require delisting prior to any deposition in the lake. Based on discussions presented in Section 3.1.1.2.2 and in the other two extraction alternative analyses, the EPA Regional Administrator would make the decision as to whether the extracted sediments could be considered nonhazardous and disposed of on-site. Other regulatory requirements would have to be met. These requirements would most likely fall under the jurisdiction of the Clean Water Act, particularly, Sections 401 and 404. Assuming these permits are obtained and all other ARARs are met, deep lake deposition of the treated sediments should occur.

As discussed previously in the other alternatives, substantial institutional effort would be required to carry out periodic site evaluations and five-year reviews. These long-term concerns would be manageable from an administrative viewpoint. Thus this alternative is considered to be administratively feasible.

- Cost: The capital cost for this alternative, as outlined in Table B-6, is estimated at $16,898,200. Operation and maintenance costs, outlined in Table B-12, are approximately $13,000 per year for 30 years. The present worth, valued at $17,141,000, represents all of the activities to dredge, extract with water, and deposit sediments, as well as haul and landfill hazardous treatment sludges; perform all operation and maintenance functions on the treatment system components; perform annual sampling in the lake; and perform the six required five-year reviews.

  If the extracted sediments fail to pass the leaching criterion to be considered delistable, this alternative may not be feasible. Regulatory approval to dispose of a listed hazardous waste in a recreational lake, despite the fact that the sediments were removed from the lake and would have been treated somewhat, is considered unlikely. RCRA LDR consideration would apply to the sediments if they were not delistable, therefore they would have to be disposed of in a Subtitle C hazardous waste facility (assuming they met the 1 mg/l treatability variance).

- Compliance with ARARs: The same action-specific ARARs and key regulations that apply to hydraulic dredging, extraction and supernatant treatment and discharge activities discussed in Alternative 3A are applicable for this alternative, including the U.S. Fish and Wildlife Coordination Act, the Clean Water Act and RCRA LDRs. Deposition of the extracted sediment would comply with Sections 401 and 404 of the CWA. The extracted sediment is assumed to be delistable and thus is not subject to the RCRA LDRs. It is expected that this alternative would comply with all identified ARARs.

- Overall Protection of Human Health and the Environment: Alternative 3C would provide the same overall protection of human health as discussed in Alternative 3A. The beneficial impact would include reducing the sediment ingestion cancer risk level to 1×10^{-5}. If the remaining contaminated sediment redistributes to areas where sediment ingestion is a feasible pathway, additional remedial actions would be required to adequately protect human health.

  The implementation of this alternative may improve the lacustrine ecosystem by reducing the potential exposure pathways of the arsenic contaminants to the fish and wildlife.

- State Acceptance: No state comments have been received to date.

- Community Acceptance: No public comments have been received to data.

4.2.7 Alternative 5 - In-Situ Sand Covering

4.2.7.1 Description

The major feature of this alternative involves the placing of clean coarse sand atop contaminated sediments that exceed the action level of 120 mg/kg for arsenic and are located within an area bounded by the lake shoreline and the 2.5-foot lake water column depth. The coarse sand would be distributed to those contaminated areas via a barge equipped with pneumatic pumps for dry materials handling or diffuser discharge heads for the deeper portions of this area, or would be spread by trucks or front-end loaders and graded in the shallower areas.

Long-term monitoring of the lake would be required to evaluate the performance of this alternative. The monitoring would consist of an annual inspection of the site, as well as environmental sampling and chemical analysis of the samples for arsenic. If it is determined that the coarse sand cover has been significantly distrupted or does not meet the intended use, additional clean coarse sand may be required for application and regrading. Because this alternative would result in contaminated sediment remaining on-site, CERCLA as amended would require that the site must be reviewed every five years.

The major work items associated with this alternative includes:

- Mobilization/demobilization of equipment and operations

- Delivery of clean coarse sand (incremental applications)

- Apply and grade (where necessary) coarse sand cover in those areas identified

- Conduct annual inspection of the site to determine if conditions have changed dramatically, or if the cover has been significantly disrupted

- Conduct annual sampling of the lake sediment and lake water and analyze for arsenic to monitor contaminant concentrations and any associated migration

- Assess whether the sand cover meets the remedial objectives for this alternative, and identify the need for any additional clean sand cover and regrading

- Perform site reviews every five years

4.2.7.2 Assessment

o Short-Term Effectiveness: The short-term effectiveness concerns associated with this alternative include public health threats and adverse impacts on the environment.

The covering of the contaminated sediments from the lake shoreline to a water depth of 2.5 feet may have significant impacts on the lake ecosystem. The application of the one-foot coarse sand cover and any grading activities may result in temporary sediment and sand particulate suspension. However, as the areas of remediation are relatively shallow, particulates would settle within a short period of time. The shoreline would essentially be regraded. Pooled areas of quiescent water, which serve as hatching and/or feeding areas, may be eliminated. As a result, direct adverse impacts may occur to the habitats of biota, fish and wildlife.

It is estimated that during the implementation of this alternative, approximately 10,000 truckloads of clean coarse sand (13 cubic yards per load) would be required to provide enough cover material. As a result of the increased traffic conditions, temporary increases in noise and air pollution levels and the occurrences of vehicular accidents may be associated with the construction activities. In addition, transferring the clean sands to barges or dumping sands for grading may result in fugitive dust emissions. However, the impact of each of these temporary conditions can be minimized through the implementation of appropriate construction control plans, traffic control plans, and dust control measures (e.g., water spray).

Construction workers would not come into direct contact with the contaminated sediments, as no excavation or handling of contaminated sediments would be involved. Coarse sand application at the 2.5-foot water level would be accomplished through the use of barge and pneumatic pumps. The sand would be discharged from the pump hose below the water surface. Sand would be applied to the contaminated sediments by truck or front-end loader, and then regraded. As previously mentioned, fugitive dust may be emitted during the transfer of clean sands to the appropriate application equipment. Since this is clean sand, appropriate dust control measures could be employed to minimize worker and public exposure.

- Long-Term Effectiveness: The coarse sand cover would reduce the potential of ingestion of those sediments identified in the risk assessment as a public health risk. Therefore the cancer risk in the areas of remediation would be reduced to 1×10^{-5}. However, only five percent of the arsenic contained in the lake would be covered. Several instances could arise whereby arsenic contamination could be redistributed. Incoming water to the lake from the river could carry additional arsenic contamination, which could subsequently adsorb onto the sediments. Natural water dynamics; human disturbance of the sediments or cover during swimming or jogging; children digging in the sand cover; or the growth of vegetation are examples of mechanisms that may redistribute contaminated sediments. Any of these occurrences may result in previously clean sediment areas exceeding the action level, or may result in previously contaminated areas becoming clean. Therefore, annual monitoring would be required to measure the effectiveness of this alternative and monitor the redistribution pattern of the lake sediment.

  Because this alternative would result in the contaminated sediments remaining on-site, CERCLA as amended would also require that the site be reviewed every five years to determine the effectiveness of the alternative or if new technologies could be applied to the problems at this particular site.

  Based upon the review of the annual monitoring program findings, an assessment would be made to determine if the objectives set for this alternative are met. The level of certainty for this alternative in meeting the objectives is low due to untreated residual contamination remaining in the lake. Additional clean coarse sand may be required in new or already covered areas, or regrading may be performed. If chemical data reveal significant levels of arsenic, additional steps for remediation may be implemented.

- Reduction of Toxicity, Mobility, or Volume: As a result of the implementation of this alternative, there would be no reduction in the toxicity or volume of contaminated sediments in the lake. The sand cover would act as a temporary measure to reduce the potential for ingestion of the contaminated sediments located in the shallow waters of the lake. This cover would significantly reduce the physical mobility of arsenic from the removed sediments, but would not eliminate potential exposure to the underlying sediments, as the cover may easily be distrupted or scoured. In addition, the potential for the leaching of arsenic from the contaminated sediments into the lake water or adsorbing to the clean sand or other sediments still exist due to the high permeability of the cover material.

- Implementability

  Technical Feasibility: The application of the coarse sand cover is a relatively simple and conventional technique that may be accomplished through the use of pneumatic pumping and barges, or dumping via trucks and/or front-end loaders with grading. Coarse sand is a common construction material that is locally available. Associated difficulties with this particular application involve the potential for sediment disturbance and resuspension by the barge at shallow water depths (i.e., 2.5 feet), and by the physical application of the cover sand. As there are contaminated sediments above the action level that are located immediately outside the 2.5-foot water level remediation areas, there is a potential that a high degree of turbulence would resuspend or disperse the uncovered contaminated sediments. These sediments could then settle atop the clean sand cover. Considerations must be given when selecting the barge type to the minimum clearance required by the barge with a full load and location of the barge's propeller to minimize this potential disturbance.

  Application techniques may also be selected in order to minimize the potential for contaminated sediment disturbance. Point dumping from the truck or from a front-end loader would tend to resuspend the sediment and result in high turbidity in the vicinity of the operations. Pumpdown methods, as with barges and pneumatic pumps, could be used to reduce the amount of sediment disturbance, resuspension, and turbidity increase in the surrounding water by discharging the cover material close to the surface of the sediments. However, the typical method of operation may require modification in order to work in the shallow waters for Union Lake. Upon application of these techniques, it may be difficult to ensure that the one-foot of sand cover extends over the submerged contaminated sediments. In the more shallow areas of the lake sediments to be covered, it would be easier through the use of grading equipment to establish the one-foot sand cover. Another technique, a submerged diffuser system, could be used to reduce the turbidity resulting from the cover application, decrease scouring of the area, and also provide a more accurate system by which the one-foot cover could be applied. The diffuser head could cause radial divergence of the flow of the cover material, thereby reducing the discharge velocity of the applied cover material to acceptable levels. By varying the height of the discharge above the contaminated sediment as well as the discharge velocity, impact of the velocity and the thickness of the cover can be controlled. In addition, there may be certain remediation areas that will not be accessible without private authorization by either the truck/front-end loader dumping and grading method or the barge method without disrupting the sediment. Additional consideration would be required when addressing any areas of limited access.

Should the annual monitoring program reveal that significant levels of arsenic are present, or that the sand cover is not providing the level of protection intended by its use, then additional measures would be required. These measures may include the additional application of more clean sand cover, regrading existing cover areas, or, if conditions warrant it, excavating and/or treating the contaminated matrix (e.g., sediment or water). The present alternative actions would generally not interfere with any of these additional measures. However, in order to excavate or treat those sediments that have already been covered, additional material handling, and perhaps an increased volume for treatment, would be required.

The major limitation associated with this alternative is that the feasibility and effectiveness of the method employed has not been fully demonstrated for the containment of hazardous waste contaminated sediments. Covering methods have been utilized at several sites recently, but the long-term reliability and effectiveness of this alternative is not yet known.

Administrative Feasibility: The implementation of this alternative would result in the modification of a water body. As such, coordination with the U.S. Fish and Wildlife Services must be performed prior to the implementation of the alternative. As access to certain areas of the lake sediments requiring sand covering may be difficult from public property, coordination with private homeowners to obtain access may be required. As required by CERCLA, as amended, the site must be reviewed every five years to determine the effectiveness of the alternative of if new technologies could be applied to the problems at this particulate site. As no treatment or disposal is anticipated, no additional permits are required and RCRA CDR considerations are not applicable to this alternative.

The trucks delivering the estimated 130,000 cubic yards of clean coarse sand would be scheduled based upon assumed application rates. While limited storage would be available at the public beach, the area is not of sufficient size to accommodate the entire load required for alternative implementation. Administrative effort would be required to schedule the delivery of the sand so as not to delay the project.

- <u>Cost</u>: The capital cost for this alternative, as outlined in Table B-7, is estimated at $3,043,100. Operation and maintenance costs, outlined in Table B-13, are approximately $13,000 per year for 30 years. The present worth, valued at $3,313,100, represents all of the activities required to place a one-foot layer of sand over the 130,000 square feet of contaminated sediment; conduct annual sampling in the lake; and perform the six required five-year reviews.

- <u>Compliance With ARARs</u>: The U.S. Fish and Wildlife Coordination Act requires that the appropriate agency exercising jurisdiction over a wildlife resource, and the U.S. Fish and Wildlife Service, be consulted before undertaking any action that modifies a water body. Special attention must be given to the impact on wetlands and flood plains (lake shores) in accordance with Executive Orders 11990 and 11888. Placement of a one-foot sand layer over 87 acres in the lake would constitute modification of a water body. Therefore, coordination with the proper agency and the U.S. Fish and Wildlife Service would be conducted to ensure that this alternative would comply with this ARAR. In addition, the National Endangered Species Act requires that special attention be given to the impact on areas where endangered species reside.

  The placement of the sand layer would constitute a discharge according to the CWA. Section 401 and Section 404 specify that the existing contaminant levels not be violated and that no remedial alternative affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. As the sand would be from a clean source, the chemical, physical and biological integrity of the lake would not be violated. This alternative results in minimal temporary and localized impacts to the wetland except the possible installation of access roads. These access roads would be demolished after the completion of the remediation and the wetland would be restored to its original condition with minimal impact.

Activities during this remediation would be subject to OSHA industry standards and regulations.

Because this alternative does not involve any removal, treatment or placement of wastes, RCRA LDR is not applicable.

- o <u>Overall Protection of Human Health and the Environment</u>: This alternative would not involve any removal or treatment of the contaminated sediments identified as a public health risk. It would provide a type of containment of the sediment by placing a one-foot sand layer atop those sediments. This cover would reduce the potential for sediment ingestion, thus reducing the cancer risk level to 1×10^{-5}. Natural sediment redistribution patterns, human disturbance and vegetation growth may cause sediments with concentrations greater than 120 mg/kg to collect in areas where sediment ingestion is feasible. If this occurs additional remedial actions would be required to meet the target cancer risk level of 1×10^{-5}.

- o <u>State Acceptance</u>: No state comments have been received to date.

- o <u>Community Acceptance</u>: No public comments have been received to date.

4.3 COMPARISON AMONG ALTERNATIVES

A comparative analysis will be conducted in this section to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another.

The following lists the alternatives to be compared in this section:

Alternative 1:	No Action
Alternative 2A:	Dredging/Thickening/Fixation/Off-Site Nonhazardous Landfill
Alternative 2B:	Dredging/Thickening/Fixation/On-Site Nonhazardous Landfill
Alternative 3A:	Dredging/Extraction/Sediments to Off-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal

Alternative 3B:	Dredging/Extraction/Sediments to On-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal
Alternative 3C:	Dredging/Extraction/Deep Lake Deposition for Sediments/Off-Site Hazardous Sludge Disposal
Alternative 5:	In-Situ Sand Cover

4.3.1 Short-Term Effectiveness

The implementation of Alternative 1 would result in minimal short-term effects to the local community. However, it could possibly restrict the use of the lake. There would be no construction involved at the site, no threat to neighboring communities, and no significant impacts on the public health and environment during the remedial action. Education programs and public meetings would be presented to the neighboring communities during the remedial action.

The implementation of Alternatives 2A, 2B, 3A, and 3C would pose potential public health threats to the neighboring communities via direct contact with spilled wastes and the inhalation of fugitive dust. While the chemicals involved in Alternatives 2A and 2B would be stored in closed silos, which are equipped with dust emission control devices, there would be a potential for limited dust emissions. In Alternatives 3A, 3B, and 3C, the chemicals utilized are either liquid or granular in nature as opposed to a fine dust. The implementation of Alternatives 2A, 2B, 3A, 3B or 3C would present minor threats to public health. Alternative 5 would present minimal threats to the community as no sediment would be removed. Potential impacts include fugitive dust emissions during placement of the sand cover. Standard construction dust-suppression techniques would minimize this threat.

During the implementation of all alternatives, on-site workers would be provided with personnel protective equipment to minimize exposures from direct contact with wastes, chemicals and the inhalation of fugitive dust.

There would be no significant adverse impacts on the environment during the implementation of Alternative 1. Alternatives 2A, 2B, 3A, 3B and 5 pose some environmental impacts, which include an increase in traffic from construction activities, the transportation of sediments, and the transportation of sand for the cover. The increased truck traffic might result in an increase in traffic accidents. The construction activity and increased truck traffic pose a potential increase in air pollution, noise pollution and increased exposure to spilled wastes. Proper traffic control and dust suppression measures would be required to minimize these short-term adverse environmental impacts. Also, dredging activities which would be conducted in Alternatives 2A, 3A, 3B or 3C could disturb wetland areas, causing possible short-term environmental impacts. Measures may have to be taken after dredging activities to restore potential wetland areas.

Implementation of Alternatives 3C and 5 may result in temporary and localized short-term impacts to the lake. Redeposition of the extracted sediments and the diffusion of sand for the covering in Alternative 5 may result in resuspension of contaminated sediments. The potential for resuspension could be minimized through the use of diffuser-type equipment. If resuspension does occur, migration of the particulate matter could be minimized through the utilization of silt curtains. Dispersion of both the treated sediments and sand would be conducted to avoid piling of the material, which could impact boating activities.

The time required to achieve protection for Alternative 1 would be approximately three to four weeks. This would include monitoring the river areas and posting warning signs. The time required to complete Alternatives 2A and 2B is estimated to be two years. Alternatives 3A, 3B and 3C are estimated to require three years for completion. One year is required for Alternative 5. The estimated time periods run from the start of construction to the completion of treatment and disposal activities.

4.3.2 Long-Term Effectiveness

The implementation of Alternative 1 would result in a large residual risk remaining on-site, as the arsenic contaminated sediment is not removed from the lake or treated in place. It would require many years for natural attenuation and transport mechanisms in the lake to significantly reduce the volume of arsenic in the sediment. This alternative would prevent the ingestion of contaminated sediments by restricting access to the river areas. The long-term effectiveness of the alternative in minimizing human health risks would depend on its success in preventing access to the site.

After implementation of either of Alternatives 2A, 2B, 3A, 3B, 3C, or 5, the sediment ingestion risk would be reduced to below the target level of $1x10^{-5}$. These alternatives would remove and treat those sediments identified as a public health risk, thus reducing the exposure risks. However, contaminated sediments with concentrations above the target level of 120 mg/kg would remain in the lake, although in areas not deemed a public health risk. If significant redistribution of the sediments occur via natural lake dynamics, human disturbance or the growth of vegetation, resulting in areas with a water depth of less than two and one-half feet containing these sediments, the public health risk would be greater than the target of $1x10^{-5}$. Thus additional remedial actions may be required.

The treated sediments from either extraction or fixation are expected to be delistable and thus could be disposed of as nonhazardous waste either in an off-site nonhazardous landfill, an on-site nonhazardous landfill or deep lake deposition. The supernatant water from the dredging and the supernatant water from the extraction are treated by standard physical-chemical wastewater treatment processes to remove arsenic to levels below 0.05 mg/l, which meets the NJPDES requirements and New Jersey Surface Water Quality Standards before the water is discharged to the lake. The arsenic contaminated sludge generated from the extraction process would be transported to an off-site RCRA treatment and disposal facility. The sludge would ultimately be disposed of in RCRA Subtitle C landfill.

Alternatives 2A, 2B, 3A, 3B, and 3C employ treatment technologies that solidify or extract arsenic in the sediments. Both technologies have been tested and are proven. All equipment necessary for implementing these alternatives is available from several vendors. The chemicals employed in the fixation and extraction processes are all readily available. Pilot-scale studies would be performed to optimize the treatment processes. After the implementation of Alternatives 2A or 3A the off-site landfill would not require a long-term management program as part of the site remedy. Alternatives 2B and 3B include disposal of treated sediments in an on-site landfill. A long-term management and maintenance program would be required for the on-site landfill facility, however, implementation of this program does not pose any problems. Long-term monitoring of sediments remaining on-site with a concentration greater than 120 mg/kg would be required for all the alternatives, to monitor for any redistribution. If these sediments collect in areas identified as posing a potential public health risk additional actions may be required.

The reliability of control in Alternative 1 is low because the long-term effectiveness of this alternative is dependent upon restriction of site access. Alternatives 2A, 2B, 3A, 3B and 3C, are not likely to fail because the arsenic is fixed in the sediments or extracted. Any remaining arsenic is assessed to be safe from a public health standpoint.

Alternative 1 would not reduce human health risks in Union Lake. Alternatives 2A, 2B, 3A, 3B, 3C and 5 would all reduce human health risks via the sediment ingestion pathway. As discussed previously, the source of arsenic into the lake water from the ViChem plant site must be eliminated to reduce the overall human health risks in the lake areas. This remedial action to manage migration should be taken before any remedial action is taken on the lake sediments.

4.3.3 Reduction of Toxicity, Mobility or Volume

Alternatives 1 and 5 do not reduce the toxicity, mobility or volume of the contaminants because no arsenic is removed from Union Lake. Alternatives 2A, 2B, 3A, 3B, and 3C permanently reduce the mobility and the volume of contaminants in the lake. Alternatives 2A and 2B reduce the toxicity of the sediments in the lake, but not overall. Fixation does not change the toxicity of the arsenic; the contaminant becomes immobilized within a tightly bound matrix. Alternatives 3A, 3B, and 3C reduce the toxicity of the sediments in the lake. The form of arsenic is changed via the extractant treatment process and consolidated into a sludge for off-site hazardous waste disposal. Alternatives 2A and 2B produce a larger volume of treated sediment to be disposed of than Alternatives 3A, 3B, and 3C, because the fixation process requires large volumes of additives.

Both on-site and off-site nonhazardous landfilling options offer similar reduction of mobility from treated sediments. Deep lake depositions of water-washed sediments associated with Alternative 3C may further reduce contaminant mobility in the lake if the treated solids are placed over contaminated sediment on the lake bottom. Overall, Alternatives 2A, 2B, 3A, 3B, and 3C provide permanent and essentially irreversible remedies for treatment of the contaminated sediments.

4.3.4 Implementability

The implementation of Alternative 1 consists of simple tasks, such as monitoring, inspection of the lake and posting warning signs. These tasks present no implementation difficulties. The implementation of either Alternative 2A, 2B, 3A, 3B, or 3C involves the use of standard equipment that is commercially available. There is no technology involved in Alternative 1, whereas in Alternatives 2A, 2B, 3A, 3B, and 3C, the technologies are well developed and proven. The implementation of Alternative 5 requires standard construction equipment and fill material. Technology considerations for placing a layer of sand over a contaminated sediment in shallow water are minimal.

After the implementation of Alternatives 1 and 5, if additional remedial action is necessary it can be implemented with no anticipated problem. In Alternatives 2A, 2B, 3A, 3B, and 3C, it is not anticipated that there would be a need for future or additional remedial actions. In the event that additional action is required, there would be no technical difficulties to overcome when implementing the task.

With the application of Alternative 1, there is a need for surveillance in order to attain effective access restriction. Regular public awareness meetings would be required to increase the effectiveness of this alternative. With the application of either Alternatives 2A, 2B, 3A, 3B, 3C, or 5, long-term operation and maintenance activities would include periodic site sampling, performing five-year reviews, and monitoring on-site landfills (Alternatives 2B and 3B). The processes are reliable and would meet the designated efficiencies and performance goals.

For the implementation of Alternatives 1 and 5, no permits are required. Alternatives 2A, 2B, 3A or 3B, may require some permits. In carrying through all the alternatives, coordination would be required with other agencies to obtain all necessary agreements, particularly for Alternatives 2B and 3B, which involve constructing an on-site nonhazardous landfill facility.

Treatment capacity and disposal service requirements are not required in Alternatives 1 and 5. Treatment capacity, storage capacity and disposal services are all adequately available for Alternatives 2A, 2B, 3A and 3B. The nonhazardous off-site landfills have the capacity to handle the treated sediments. The nonhazardous on-site landfill would be designed to contain the total amount of the treated sediments. The relocation of sediment involved in Alternative 3C should not place any burden or drastically disrupt the ecosystem of Union Lake.

The availability of necessary special equipment and personnel are not required for Alternatives 1 and 5. Standard equipment and operations utilized in Alternatives 2A, 2B, 3A, 3B, and 3C are commercially available.

Bench scale tests have proven that fixation (Alternatives 2A and 2B) and extraction (Alternatives 3A, 3B, and 3C) are feasible for treating the arsenic-contaminated sediments. However, pilot-scale tests are required to provide relevant design criteria for the remedial design. Pilot-scale tests will be performed if these alternatives are selected. Since further testing is required, general comparisons between fixation and extraction treatment processes cannot be made on implementability criteria. The off-site landfill disposal would be preferred over the on-site landfill disposal. Deep lake deposition may be preferred administratively to landfilling, not only for its technical ease, but also for the additional purpose it may serve by immobilizing any arsenic present in deeper areas of the lake.

4.3.5 Cost

Table 4-3 presents a summary of the costs developed for each of the alternatives. The total present worth for Alternative 1 is estimated at $839,600 based on a 30-year period and a 5% discount rate. This includes capital costs, annual operation and maintenance costs and six five-year reviews.

The total present worth of Alternatives 2A, 2B, 3A and 3B ranged from a low of $3,313,000 for Alternative 5 to a high of $79,304,000 for Alternative 2A.

TABLE 4-3

SUMMARY OF COST ANALYSIS (1989 DOLLARS)
SOURCE CONTROL

ALTERNATIVE	CAPITAL COST DIRECT	CAPITAL COST INDIRECT	CAPITAL COST TOTAL	ANNUAL O&M	PRESENT WORTH; DISCOUNT RATE OF 5%
1	35,000	9,450	44,450	47,200	839,580
2A	62,249,660	16,812,347	79,062,007	13,020	79,304,454
2B	45,520,840	12,290,627	57,811,467	92,730	59,112,407
3A	23,490,295	6,342,385	29,832,680	13,020	30,075,127
3B	15,589,346	4,209,124	19,798,470	59,060	20,652,296
3C	13,305,695	3,592,545	16,898,240	13,020	17,140,687
5	2,396,160	646,960	3,043,120	13,020	3,312,820

Based on the present worth analysis, there are slight differences among Alternatives 2A, 2B, 3A, 3B, and 3C. The differences are most heavily dependent upon chemical costs, in which fixation outweighs extraction and landfilling location options, which indicate that on-site is preferable to off-site. Deep lake deposition, the disposal option for Alternative 3C, is less costly than both landfilling options. Alternative 5, in-Situ sand covering, does not include any chemical, disposal, or treatment costs, and is thus the least costly of all the remedial action alternatives. Without considering implementability and other factors other than cost, Alternative 3C, extraction with deep lake deposition, would appear to be the most economical alternative.

4.3.6 Compliance with ARARs

Action-specific ARARs for Alternative 1 apply to the posting of warning signs and the site-monitoring activities. Requirements for these activities include OSHA Health and Safety Standards and RCRA Facility standards. Alternative 1 would meet OSHA Health and Safety Standards, but it is not expected to meet RCRA Closure/Post Closure requirements specified in 40 CFR 264.10-264.120 because it would not remove or contain the contaminated material.

Hydraulic dredging activities in the lacustrine areas would require appropriate preventive measures to minimize resuspension, erosion and dissolved oxygen depletion in order to comply with the requirements of the Federal Rivers and Harbors Act Section 10. The Clean Water Act Section 404 requires that no activity affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. Alternatives 2A, 2B, 3A, 3B and 3C would remove contaminants from the lake with minimal disturbance to the wetland. After the completion of the remediation, any wetlands that have been disturbed would be restored to their original conditions with minimal impact on them.

The U.S. Fish and Wildlife Coordination Act requires that the appropriate agency exercising jurisdiction over wildlife resources, and the U.S. Fish and Wildlife Service, must be consulted before undertaking any action that modifies a body of water. Special attention must be given to the impact on wetland and floodplains (lake shore) in accordance with executive order 11990 and 11888. This is not applicable to Alternative 1 because it does not modify a water body in any way. Alternatives 2A, 2B, 3A, 3B, 3C and 5 would be expected to comply with this regulation if implemented.

All alternatives would have to comply with RCRA facility standards and OSHA industry standards and regulations concerning hazardous wastes. RCRA 40 CFR 261 and 262 are applicable to activities including dredging hazardous sediments, transferring these materials to a treatment facility, and removing hazardous materials through a fixation process (Alternatives 2A and 2B) or a chemical extraction process (Alternatives 3A and 3B and 3C). Alternative 1 would not be subject to these ARARs because this alternative would not remove or contain any contaminated sediments.

RCRA LDRs restrict the placement of wastes into land disposal facilities. The fixated and extracted wastes are expected to be delistable as discussed in Chapter 3. The treated sediments could thus be safely disposed in a nonhazardous facility. In addition, if delisted, the extracted sediments could be deposited in Union Lake in accordance with the LDRs. As Alternative 1 and 5 do not involve any removal of the contaminated sediments, RCRA LDRs are not applicable to these alternatives.

Treatment of the wastewaters generated from Alternatives 2A, 2B, 3A, 3B, and 3C are expected to meet New Jersey State SPDES permit requirements. A NJPDES permit would not be required for on-site discharge, but the permit conditions regarding arsenic concentration (0.05 mg/l) should be met. The treated effluent would also meet the New Jersey Surface Water Quality Standards in terms of arsenic (0.05 mg/l) and other conventional parameters (such as suspended solids, pH and DO). Alternatives 2A, 2B, 3A, 3B and 3C would treat the dredged supernatant for suspended solids and arsenic removal and the effluent would then be discharged back to the lake. The disposal of the supernatant would comply with the EPA guidelines for disposal of dredged or fill material (40 CFR 280) by restoring and maintaining the chemical, physical and biological integrity of river water in accordance with the Clean Water Act (CWA Section 401).

The treated sediments would be delistable and considered nonhazardous. DOT rules for transporting hazardous waste would not be applicable to Alternative 2A. However, the extraction alternatives, Alternative 3A, 3B and 3C, produce an arsenic-contaminated sludge that would be transported to a RCRA facility for treatment and disposal. Therefore transport of the sludges would be in accordance with DOT rules. For all the alternatives involving off-site disposal the Clean Air Act and National Ambient Air Quality Standards would be applicable in regulating particulate air emission arising from handling and transporting the stabilized materials. Adequate dust-suppression measures would be provided for any potential fugitive dust emissions. These considerations may not apply to Alternatives 2B and 3B, as treated soils are disposed of at an on-site landfill. Alternative 1 does not involve any treatment or transportation; therefore these ARARs would not apply.

The New Jersey Solid Waste Regulation (NJAC 7:26), particularly subchapter 2A - Additional Specific Disposal Regulation for Sanitary Landfills (May 5, 1986), would be considered in managing treated nonhazardous wastes for both on-site and off-site landfills under Alternatives 2A, 2B and 3A or 3B.

4.3.7 Overall Protection of Human Health and the Environment

Alternative 1 would entail no removal, containment or treatment of the contamination source. It would not contribute to the protection of human health and the environment since there would not be any reduction in the toxicity, mobility or volume of contaminants. Many years would be required for natural attenuation to reduce arsenic-contaminated sediments in the lake to below the cleanup criterion of 120 mg/kg. This alternative is not considered responsive to the remedial objectives, but provides a "base case" for comparison among other alternatives.

Alternatives 2A, 2B, 3A, 3B and 3C involve actual removal and treatment of the contaminated sediments identified as a public health threat (chemical fixation for Alternatives 2A and 2B and chemical extraction for Alternatives 3A and 3B) to affect permanent immobilization or extraction of arsenic compounds. Using these alternatives to remove the contaminated source, and assuming that there is no significant redistribution of the remaining contaminated sediments and that the contaminated groundwater entering the lake from the ViChem site is controlled, protection of human health and the environment would be achieved. Fixation and extraction processes would prevent future releases of arsenic into the environment. Alternatives 2A, 2B, 3A and 3B would contain treated sediments in a nonhazardous landfill, minimizing the chances of further exposure to the contaminants. Alternative 3C would deposit the treated sediments in a deep portion of Union Lake. These clean sediments would not pose a risk to public health and may minimize the redistribution of the potentially contaminated sediments located deep in the lake. Treated sediments can be classified as nonhazardous and pose little or no risk to groundwater or surface water quality. The removal of contaminated sediments in Alternatives 2A, 2B, 3A, 3B, and 3C would attain the cleanup criterion of 120 mg/kg in areas posing a public health risk and reduce the sediment ingestion cancer risk level to the target level of 1×10^{-5}. Alternative 5 would sufficiently isolate the sediments and also reduce the cancer risk level via sediment ingestion to the target level. It is assumed that shortly after the implementation of measures for the successful management of groundwater migration at the ViChem facility, and completion of remedial activities in the river and lake areas, the lake risks would be sharply reduced. Any remaining contaminated sediments would contain levels of arsenic below the action-level for the lake and not deemed as a public health risk.

State Acceptance

No state comments have been received to date.

Community Acceptance

No public comments have been received to date.

4.4 SUMMARY OF DETAILED ANALYSIS

Table 4-4 summarizes the alternatives analysis discussed in the previous sections. A brief description of the key points in each of the nine evaluation criteria is presented.

In addition to the previous discussions, several other factors should be considered when selecting a remedial alternative for the River Areas. These factors are listed below:

- The source of arsenic into Union Lake is the groundwater discharge from the ViChem plant. The data suggests that eliminating this source should improve the downstream surface water quality. Therefore this source should be eliminated before any downstream remedial actions are taken.

- The Maurice River contains substantial quantities of arsenic in the sediments, which may need to be remediated. It would be prudent to initiate sediment remedial actions in the rivers before remediating sediments in Union Lake. Contaminated river sediments may migrate downstream into Union Lake.

- Extraction and fixation were seen as feasible remedial technologies for the soils on the ViChem site. They may also be feasible for the contaminated sediments in the Maurice River. Therefore, it may be more cost-effective to combine remedial actions in the various areas so that only one treatment system, for example, landfill, is constructed to remediate a given problem.

TABLE 4-4
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1 - No Action	Alternative 2A-Dredging/ Thickening/Fixation/ Off-Site Non-Hazardous Landfill	Alternative 2B-Dredging/ Thickening/Fixation/ On-Site Non-Hazardous Landfill
Key Components	Limiting access to site, public education programs, Site-use restrictions, Long-term monitoring	Hydraulic dredging, Sediment Fixation, Wastewater Treatment, Off-Site Non-Hazardous Landfill, Long-Term Monitoring	Hydraulic dredging, Sediment Fixation, Wastewater Treatment, On-Site Non-Hazardous Landfill, Long-Term Monitoring.
Short Term Effectiveness			
-Protection of community during remedial actions	No short-term threats to communities	Potential for direct contact of spilled waste and inhalation of fugitive dust.	Same as Alternative 2A
-Protection of workers during remediation	Personnel protection equipment required against dermal contact and inhalation during sign posting, sample collection, inspection	Minimal risk to workers. Personnel protection equipment required against direct contact with wastes and inhalation of fugitive dust	Same as Alternative 2A
-Environmental Impacts	No significant adverse environmental impacts from site activities	Increased traffic, noise, and air pollution.	Minimal increase in traffic, noise and air pollution
-Time until remediation	Many years (probably decades)	Estimated to be 2 years from start of construction to completion of remediation work	Same as Alternative 2A

9484b

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3A-Dredging/ Extraction/Sediments to Off-Site Non-Hazardous Landfill/Off-Site Hazardous Sludge Disposal	Alternative 3B-Dredging/ Extraction/Sediment to On-Site Non-Hazardous Landfill/On-Site Hazardous Sludge Disposal	Alternative 3C-Dredging/ Extraction/Deep Lake Deposition of Sediments/ Off-Site Hazardous Sludge Disposal	Alternative 5-In-Situ Sand Covering
Key Components	Hydraulic dredging, Sediment Extraction, Wastewater Treatment, Sediments to Off-site Non Hazardous Landfill, Off-Site Hazardous Sludge Disposal, Long-Term Monitoring	Hydraulic dredging, Sediment Extraction, Wastewater Treatment, Sediments to Non Hazardous Landfill, On-Site Hazardous Sludge Disposal, Long-Term Monitoring.	Hydraulic Dredging, Sediment Extraction, Wastewater Treatment, Deep Lake Deposition of Sediments, Off-Site Hazardous Sludge Disposal, Long-Term Monitoring.	In-Situ Sand Covering, Long-Term Monitoring.
Short Term Effectiveness				
-Protection of community during remedial actions	Potential for direct contact of spilled waste and inhalation of fugitive dust.	Same as Alternative 3A.	Same as Alternative 3A	Same as Alternative 3A.
-Protection of workers during remedial	Minimal risk to workers. Personnel protection equipment required to protect against direct contact with wastes and inhalation of fugitive dust.	Same as Alternative 3A.	Same as Alternative 3A	Same as Alternative 3A.
-Environmental Impacts	Increased traffic, noise, and air pollution	Minimal increase in traffic noise and air pollution	Same as Alternative 3B. Temporary adverse impacts such as resuspension of sediments may occur. Migration of suspended particulates could be controlled utilizing silt curtains.	Same as Alternative 3C
-Time until remediation	Estimated to be 3 years from start of construction to completion of remediation work.	Same as Alternative 3A	Same as Alternative 3A	Same as Alternative 3A

9484b

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B
Long Term Effectiveness			
-Magnitude of Residual Risks	Long term evaluation required for natural degradation & transport reduction	Sediments identified as a public health risk would be removed and treated. Redistribution of contaminated sediments could result in a public health risk. Treated sediments. Delistable as non-hazardous waste, supernantant water treated to NJPDES.	Same as Alternative 2A On-site landfill maintenance and monitoring required.
-Adequacy of Control	Depends on success in preventing access to the site	Proven technologies, Long term monitoring program required for remaining sediment.	Same as Alternative 2A Long-term maintenance required for on-site landfill facility.
-Reliability of Controls	Migration of contaminants from sediments to water could occur.	If significant redistribution of sediments, additional remedial actions may be required.	Same as Alternative 2A. Minimal failure of on-site landfill facility.
Reduction of Toxicity, Mobility or Volume			
-Treatment Process and Remedy	No reduction of toxicity, mobility or volume.	Reduction in mobility of treated sediment and slight reduction in volume of on-site sediments. No reduction in toxicity.	Same as Alternative 2A
-Amount of Hazardous Materials Remaining	No material removed or treated.	Sediments identified as a public health risk are removed and treated to be delistable. Remaining sediments are not considered accessible for sediment ingestion pathway.	Same as Alternative 2A.

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3A	Alternative 3B	Alternative 3C	Alternative 5
Long Term Effectiveness				
-Magnitude of Residual Risks	Sediment identified as a public health risk would be removed and treated. Redistribution of contaminated sediments could result in a public health risk. Treated sediment delistable as non-hazardous waste. Supernatant water treated to NJPDES.	Same as Alternative 3A. Long-term maintenance and monitoring for on-site landfill required.	Same as Alternative 3A. Deposited sediments would also act to contain the potentially contaminated sediments deep in the lake.	Contaminated sedments above action level would remain on-site. Sediment redistribution to top of sand cover could result in a public health risk.
-Adequacy of Control	Proven Technology. Long-term monitoring program required for remaining sediments.	Same as Alternative 3A. Long-term maintenance required for on-site landfill facility.	Same as Alternative 3A.	Long-term maintenance of sand cover would be required. Additional cover or regrading of cover may be necessary. Long-term monitoring required for remaining sediments.
-Reliability of Controls	If significant redistribution of sediments occur, additional remedial actions may be required.	Same as Alternative 3A. Minimal failure of on-site landfill facility.	Same as Alternative 3A. Minimal potential of leachate from delisted sediments deposited in lake.	Reliability of sand cover to prevent ingestion of sediments unknown. Significant long term maintenance of cover required to prevent exposure of sediments.
Reduction in Toxicity, Mobility and Volume				
-Treatment Process and Remedy	Permanent reduction in toxicity of treated sediments. Slight reduction in volume and mobility of on-site contaminnts.	Same as Alternative 3A.	Same as Alternative 3A. Reduction in toxicity and mobility of sediments. Slight reduction in volume of contaminated sediments.	No reduction in toxicity or volume of waste. Arsenic mobility would be reduced. Contaminated sediments left uncovered may redistribute to areas of potential public risk.
-Amount of Hazardous Material Remaining	Sediments identified as a public health risk are removed and treated to be delistable. Remaining sediments are not considered accessible for sediment ingestion pathway. Significant quantity of arsenic contaminated sludge generated from extraction process.	Same as Alternative 3A.	Same as Alternative 3A.	All material remaining in place.

9484b

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B
-Irreversibility of The Treatment	N/A	Treatment is essentially irreversible.	Same as Alternative 2A.
-Type and Quantity of Residual Waste	N/A	Treated waste expected to be delistable.	Same as Alternative 2A.
<u>Implementability</u>			
o <u>Technical Feasibility</u>			
- Ability to Construct Technology	No difficulty	Standard equipment Commercially available	Same as Alternative 2A
- Reliability of Technology	No technology	Well developed and proven technology Pilot scale studies required to optimize treatment.	Same as Alternative 2A
- Ease of Undertaking Additional Remedial If Necessary		Additional future remedial actions may be required.	Same as Alternative 2A
- Monitoring Considerations	Long-term monitoring required, monitoring analysis techniques available	Long-term monitoring required.	Long-term monitoring for on-site landfill and remaining sediment required. Monitoring analysis techniques available

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3A	Alternative 3B	Alternative 3C	Alternative 5
-Irreversibility of The Treatment	Treatment is essentially irreversible.	Same as Alternative 3A.	Same as Alternative 3A	No treatment.
-Type and Quantity of Residual Waste	Treated waste expected to be delistable. Arsenic sludge generated from extraction process highly contaminated.	Same as Alternative 3A.	Same as Alternative 3A	No treatment.
<u>Implementability</u>				
o <u>Technical Feasibility</u>				
-Ability to Construct	Standard equipment commercially available.	Same as Alternative 3A.	Same as Alternative 3A.	Standard equipment and material.
-Reliability of Technology	Well developed and proven technology. Pilot scale studies required to optimize treatment.	Same as Alternative 3A.	Same as Alternative 3A. Reliability of deep lake deposition of delisted sediments is high.	Reliability of effectiveness of sand cover is unknown. Expected to be fairly good.
-Ease of Understanding Additional Remediation If Necessary	Additional future remedial actions may be required.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Monitoring Considerations	Long-term monitoring required.	Same as Alternative 3A. Long-term monitoring for on-site landfill required. Monitoring analysis techniques available.	Same as Alternative 3A.	Same as Alternative 3A.

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B
o Administrative Feasibility			
-Ability to obtain Approvals	Permits not required.	Delisting approval required from EPA Headquarters.	Delisting approval required from EPA Region II. As the site is a CERCLA site, permits for landfill are not required.
-Coordination with Other Agencies	Coordination required.	Coordination required.	Intensive coordination required for on-site landfill facility.
-Availability of Services & Materials			
-Availability of Treatment Capacity & Disposal Services	Not required	Treatment capacity and storage capacity are all adequately available. Off-site landfill requires administrative acquisition.	Same as Alternative 2A. On-site landfill provides higher availability for disposal.
-Availability of Necessary Equipment & Specialists	Not required	Standard equipment and operations. No specialists required.	Same as Alternative 2A.
-Availability of Prospecitve Technologies	Not required	Prospective technologies are available. Technologies are proven in Bench Scale Tests. Pilot studies would be required to optimize process.	Same as Alternative 2A.
Costs			
o Total Capital Cost	$ 44,450	$ 79,062,000	$57,811,470
o Annual Operation and Maintenance Cost	$ 47,200	$ 13,020	$ 92,730
o Present Worth	$839,580	$ 79,304,455	$59,112,410

9484b

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3A	Alternative 3B	Alternative 3C	Alternative 5
o Administrative Feasibility				
-Ability to obtain Approvals	Delisting approval required from EPA headequarters	Delisting approval required from EPA Region II. As the site is a CERCLA site, permits for landfill are not required.	Same as 3A. Approval for deep lake deposition may be difficult to obtain.	Should not pose a problem.
-Coordination with Other Agencies	Coordination required for identification of off-site hazardous landfill and hazardous landfill.	Intensive coordination required for on-site landfill facility and identification off-site hazardous landfill.	Coordination required for approval of deep lake deposition and identification of hazardous landfill.	Coordination required.
-Availability of Services & Materials				
-Availability of Treatment Capacity & Disposal Services	Treatment capacity and storage are all adequately available. Off-site landfill requires administrative acquisition.	Same as Alternative 3A. On-site landfill provides higher availability for disposal.	Treatment capacity, storage capacity and disposal capacity are all adequately available.	No treatment or disposal.
-Availability of Necessary Equipment & Specialists	Standard equipment and operations. No specialists required.	Same as Alternative 3A.	Same as Alternative 3A.	Same as Alternative 3A.
-Availability of Prospective Technologies	Prospective technologies are available. Technologies are proven in Bench-Scale Studies. Pilot-Scale studies required to optimize process.	Same as Alternative 3A.	Same as Alternative 3A.	Not required.
Costs				
o Total Capital Cost	$29,832,680	$19,798,470	$16,898,240	$3,043,120
o Annual Operation & Maintenance Cost	$ 13,020	$ 59,060	$ 13,020	$ 13,020
o Present Worth	$30,075,120	$20,652,300	$17,140,690	$3,312,820

9484b

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 1	Alternative 2A	Alternative 2B
Compliance with ARARs			
-Compliance with contaminant-specific ARARs	No contaminant-specific ARAR established for arsenic contaminated sediment. Will not meet health based levels.	No contaminant-specific ARAR established for arsenic contaminated sediments. Will meet health based levels.	Same as Alternative 2A
-Appropriateness of waivers	Not justifiable	Treatability variance may be required.	Same as Alternative 2A
-Compliance with action-specific ARARs	All appropriate and relevant RCRA closure/post-closure requirements in 40 CFR 264, 110-264, 120 would not be met.	All action-specific ARARs will be met	Same as Alternative 2A
-Compliance with appropriate criteria, advisories, and guidance	Not in compliance with state and local criteria and federal advisories.	Will be in compliance with State and local criterias and federal advisories.	Same as Alternative 2A
Overall Protection of Human Health and the Environment	Risk of direct contact with contaminated sediment and water controlled but not eliminated. Contaminants remain on-site and their toxicity, mobility or volume unaltered. Cancer risk at 10^{-2} level.	Risk sediment ingestion reduced. Contaminants removed and chemically fixed to reduce toxicity and eliminate mobility. Volume of fixed solids will increase by 17%. Cancer risk level for those sediments identified as a public health risk reduced to 1×10^{-5}.	Same as Alternative 2A
State Acceptance	No state comments have been received to date.	Same as Alternative 1	Same as Alternative 1.
Community Acceptance	No public comments have been received to date.	Same as Alternative 1	Same as Alternative 1.

TABLE 4-4 (Cont'd)
SUMMARY OF ALTERNATIVE ANALYSIS

Assessment Factors	Alternative 3A	Alternative 3B	Alternative 3C	Alternative 5
Compliance with ARARs				
-Compliance with contaminant-specific ARARs	No contaminant-specific ARAR established for arsenic. Treated sediment will meet health based levels.	Same as Alternative 3A	Same as Alternative 3A	Will not meet health based level
-Appropriateness of waivers	Treatability variance may be required.	Same as Alternative 3A	Treatability variance may be required.	Not required
-Compliance with action-specific ARARs	All action-spefic ARARs will be met	Same as Alternative 3A		
-Compliance with appropriate criteria, advisories, and guidance	Will be in compliance with state and local criteria and federal advisories	Same as Alternative 2A		
Overall Protection of Human Health and the Environment	Risk sediment ingestion reduced. Contaminants removed and extracted and converted to non-hazardous form. Volume of contaminants unchanged. Cancer risk level for those sediments identified as a public health risk reduced to 1 x 10^{-5} level.	Same as Alternative 3A	Same as Alternative 3A	Risk of sediment ingestion reduced. Cancer risk level for those sediments identified as a public health risk reduced to 1 x 10^{-5}. These contaminants remain on-site.
State Acceptance	No state comments received to date.	Same as Alternative 3A	Same as Alternative 3A	Same as Alternative 3A
Community Acceptance	No public comments received to date	Sames as Alternative 3A	Same as Alternative 3A	Same as Alternative 3A

REFERENCES

Ebasco, 1988a. Vineland Chemical Company Site, Draft Feasibility Study, Vineland Chemical Company Site, Ebasco Services Inc., September 1988.

Ebasco 1988b. Vineland Chemical Company Site, Draft Remedial Investigation, Union Lake, Ebasco Services Inc., June 1988.

Faust, Samuel D., A. Winka, T. Belton, and R. Tucker, 1983. Assessment of the Chemical and Biological Significance of Arsenical Compounds in a Heavily Contaminated Watershed Part II. Analysis and Distribution of Several Arsenical Species, J. Environ. Sci. Health A18 (3): 389-411, 1983.

Hill, Richard, Understanding the First-Third Land Ban Rulemaking, The Generators Journal, Winter 1988, pp 10-15.

Lee, J. and R. Rosehart, 1982. Arsenic Removal By Sorption Process From Wastewaters, Canadian Mining Institute Bulletin, November 1982, page 33-37.

NJDEP, 1984. New Jersey Solid and Hazardous Waste Management Regulations, New Jersey Administrative Code, Title 7, NJDEP, Chapter 26, November 20, 1984.

NJDEP, 1986. New Jersey Department of Environmental Protection, Office of Science and Research Memorandum, April 8, 1986.

USEPA, 1984. Review of In-Place Treatment Techniques For Contaminated Surface Soils, Volume 1: Technical Evaluation, EPA, September 1984.

USEPA, 1985a. Guidance on Feasibility Studies Under CERCLA, Hazardous Waste Engineering Research Laboratory, Office of Research and Development, EPA Cincinnati, Ohio, May 1985.

USEPA, 1985b. Handbook of Remedial Action at Waste Disposal Sites, EPA/626/6-85/006, October, 1985.

USEPA, 1985c. Compendium of Costs of Remedial Technologies at Hazardous Waste Sites, EPA Hazardous Waste Engineering Research Laboratory, Environmental Law Institute, 1985.

USEPA 1985d. General Clarification of the VHS Model and Its Application, Federal Register/Vol 50 No. 229/ Wednesday, November 27, 1985

USEPA, 1986a. RCRA/CERCLA Alternative Treatment Technology Seminar, EPA, May 1986.

USEPA, 1986b. Handbook for Stabilization/Solidification of Hazardous Wastes, EPA/540/2-86/001, June 1986.

USEPA, 1986c. Mobile Treatment Technologies For Superfund Wastes, EPA 540/2-86/003 (F), September 1986.

USEPA, 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, EPA Office of Emergency and Remedial Response, Office of Solid Waste and Emergency Response, OSWER Directive 9335, 3-01, Draft, March 1988.

USEPA 1988b. Docket Report on Health-Based Regulatory Levels and Solubility Used in the Evaluation of Delisting Petitions, Submitted under 40 CFR 260.20 and 260.22, Science Applications International Corporation for Variances Section, Assistance Branch, Office of Solid Waste, Contract No. 68-01-7624, June 1988.

USEPA Memorandum from David A Topping, Jr. to James R. Kent, "Computed values of predicted concentrations using the UHS model", Office of Solid Waste and Emergency Response, July 1986.

Winka, A.J., 1985. An Assessment of the Arsenic Concentrations and Arsenic Species in the Lower Maurice River, Drainage Basin (NJ). Ph.D. Dissertation, Rutgers University Graduate School - New Brunswick, December 1985.

APPENDIX A

BREAKDOWN OF MAJOR FACILITIES

AND

CONSTRUCTION COMPONENTS FOR REMEDIAL ALTERNATIVES

9337b

TABLE A-1

ALTERNATIVE 1 - NO-ACTION
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/Construction	Estimated Quantities	Description
1. Posting of Warning Signs	75	14 ft x 3 ft PVC signs on 6 ft posts along lake perimeter located approximately 500 ft apart.
2. Public Awareness Program	2	1 public meeting and 1 public workshop

9337b

TABLE A-2

ALTERNATIVE 2A - DREDGING/THICKENING/FIXATION/OFF-SITE NON-HAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION		
1. Support Facilities	5	Trailers for a) EPA/DEP Office b) Engineer Office c) Health/Safety (Decontamination Equipment) d) Contractor Office e) Contractor's Equipment.
2. Security Fence & Gate	1,000 ft	8 ft high, all metal, 45° inclined barbed wire, double frame gate, each 12 ft wide, 8 ft high.
3. Parking Area	100 ft x 100 ft	1 ft thick crushed stone pavement.
4. Access Road	1,000 ft x 25 ft	1 ft thick crushed stone and drain ditch.
II. SEDIMENT HYDRAULIC DREDGING	351,000 cy	Dredge sediments to 1.0 ft depth over 81 acres using two units of "Mudcat" dredge Model MC-915 @ 50 cy/hr each with one common pontooned floating pipeline to treatment plant. Total dredging rate of 800 cy/day (350 gpm contains 10-20% solids by volume)
III. SEDIMENT GRAVITY THICKENING SYSTEM		
1. Gravity Thickeners	2	Two 42 ft diameter gravity thickeners, steel tank, 10 ft sidewall depth, bottom slope 3 in./ft, built on site, heavy duty rake mechanism, lift-up type.
2. Sediment Pumps	2	150 gpm each, diaphragm pumps.
IV. SUPERNATANT TREATMENT SYSTEM		
1. Coagulator - Clarifiers	2	Two 20 ft diameter coagulator - clarifiers, steel tank, 10 ft sidewall depth, bottom slope 3 in./ft, built on-site, heavy duty rake mechanism, with rapid mixing, coagulation/flocculation and sedimentation chambers.
2. Sludge Pumps	2	10 gpm each, diaphragm pumps.
3. Coagulant Feeding Pumps	2	Metering pumps, each 60 gph, stainless steel 316.
4. Coagulant Day Tank	1	500 gal day tank, fiberglass reinforced polyester with one mixer.
5. Polymer Feeding Pumps	2	Metering pumps, each 20 gph, stainless steel 316.

TABLE A-2 (Cont'd)

ALTERNATIVE 2A - DREDGING/THICKENING/FIXATION/OFF-SITE NON-HAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
IV. SUPERNATANT TREATMENT SYSTEM (Cont'd)		
6. Polymer Day Tank	1	200 gal day tank, fiberglass reinforced polyester with one mixer.
7. Ferric Chloride Feeding Pumps	2	Metering pumps, each 60 gph, stainless steel 316.
8. Ferric Chloride Day Tank	1	500 gal day tank, fiberglass reinforced polyester with one mixer.
V. CHEMICAL FIXATION SYSTEM		
1. Slurry Mixing Tanks	2	3,500 gal steel tanks, each with 20 min mixing time.
2. Mixers	2	Turbine impellers with 6 ft flat blades.
3. Chemical Tank (K-20 LSC)	1	3,000 gal steel tank with one mixer (one week storage).
4. Chemical Feeding Pumps	2	Metering pumps, each 60 gph, stainless steel 316.
5. Carbon Powder Silo	1	3,000 gal steel tank (one week storage) elevated steel structure support.
6. Carbon Powder Feeding Systems	2	Adjustable 25 lb/min loss in weight type dry feeder each.
7. Portland Cement Silo	1	80,000 gal steel tank (one week storage tank), elevated steel structure support.
8. Portland Cement Feeding Systems	2	Adjustable 400 lb/min loss in weight type dry feeder each.
9. Fly Ash Silo	1	20,000 gal steel tank (one week storage tank), elevated steel structure support.
10. Fly Ash Feeding Systems	2	Adjustable 100 lb/min loss in weight type dry feeder each.
VI. FIXATED SEDIMENT CURING SYSTEM		
1. Curing Basin Dike	600 ft	Top width = 3 ft, slope = 1:3, height = 2 ft bottom width = 15 ft, basin area = 150 ft x 150 ft

TABLE A-2 (Cont'd)

ALTERNATIVE 2A - DREDGING/THICKENING/FIXATION/OFF-SITE NON-HAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
VI. FIXATED SEDIMENT CURING SYSTEM (Cont'd)		
2. Clay Layer	850 cy	Local clay with 1 x 10^{-7} cm/sec permeability, 1 ft thick, 22,500 ft^2.
VII. OFF-SITE NON-HAZARDOUS LANDFILL	209,120 ton	Trucked to non-hazardous landfill facilities (within 100 miles from Union Lake), 480 ton/day.
VIII. PROCESS PIPING AND I&C		For the above treatment facilities
IX. PROCESS CHEMICALS AND MATERIALS		
1. Coagulant (Alum.)	80 ton	
2. Polymer	22 ton	
3. Ferric Chloride	80 ton	
4. K-20 LSC	638,700 gal	
5. Activated Carbon	8,520 ton	
6. Portland Cement	76,640 ton	
7. Fly Ash	25,550 ton	
X. ELECTRICAL AND POWER		For the above treatment facilities.
XI. MANPOWER		
1. Manager	1	Two years operation after one year construction
2. Supervisor	2	Two years operation after one year construction
3. Operator	4	Two years operation after one year construction
4. Labor	4	Two years operation after one year construction
XII. BUILDING, PLATFORMS & STAIRS		For the above treatment facilities
XIII. FOUNDATIONS & PADS		For the above treatment facilities

TABLE A-3

ALTERNATIVE 2B - DREDGING/THICKENING/FIXATION/ON-SITE NON-HAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SEDIMENT HYDRAULIC DREDGING	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT GRAVITY THICKENING SYSTEM	Same as Alt. 2A, Item III	Same as Alt. 2A, Item III
IV. SUPERNATANT TREATMENT SYSTEM	Same as Alt. 2A, Item IV	Same as Alt. 2A, Item IV
V. CHEMICAL FIXATION SYSTEM	Same as Alt. 2A, Item V	Same as Alt. 2A, Item V
VI. FIXATED SEDIMENT CURING SYSTEM	Same as Alt. 2A, Item VI	Same as Alt. 2A, Item VI
VII. ON-SITE HAZARDOUS LANDFILL		
1. Liner System		
o Clay Layer	24,600 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Synthetic Liner	329,000 sf	40 mil high density polyethylene (HDPE)
o Leachate Collection System		
- PVC Pipe	3,300 ft	4 in. dia perforated
- RC Sump	2	4 ft dia 6 ft deep
- Pumps	2	25 gpm each, chemical resistant
o Sand Layer	20,100 cy	2 ft thick sand layer
2. Fixated Sediment Deposition and Compaction	116,000 cy	264 cy/day
3. Capping System		
o Clay Layer	31,850 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Drainage Layer	12,200 cy	1 ft thick sand layer
o Top Soil	24,800 cy	2 ft thick topsoil
o Vegetation (Grass Seeding)	5 acres	

TABLE A-3 (Cont'd)

ALTERNATIVE 2B - DREDGING/THICKENING/FIXATION/ON-SITE NON-HAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/Construction	Estimated Quantities	Description
4. Drainage Ditch	3,320 ft	Top Width = 14 ft, Total Depth = 2 ft Side Slope = 3:1, Bottom Width = 2 ft
o Clay Layer	9,600 cy	2 ft thick clay (permeability = 10^{-7} cm/sec)
o Topsoil	3,200 cy	2 ft thick topsoil
o Vegetation (Grass Seeding)	.83 acres	
VIII. PROCESS PIPING AND I&C	Same as Alt. 2A, Item VIII	Same as Alt. 2A, Item VIII
IX. PROCESS CHEMICALS AND MATERIALS	Same as Alt. 2A, Item IX	Same as Alt. 2A, Item IX
X. ELECTRICAL AND POWER	Same as Alt. 2A, Item X	Same as Alt. 2A, Item X
XI. MANPOWER	Same as Alt. 2A, Item XI	Same as Alt. 2A, Item XI
XII. BUILDINGS, PLATFORMS & STAIRS	Same as Alt. 2A, Item XII	Same as Alt. 2A, Item XII
XIII. FOUNDATIONS & PADS	Same as Alt. 2A, Item XIII	Same as Alt. 2A, Item XIII

TABLE A-4

ALTERNATIVE 3A - DREDGING/EXTRACTION/SEDIMENTS TO OFF-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SEDIMENT HYDRAULIC DREDGING	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT EXTRACTION SYSTEM		
1. Primary Mixing Tank	2	Two 60,000 gallon steel tanks with mixers.
2. Separator	1	14-6 in. soft rubber lined hydroclones mounted in parallel. 7 operating, 7 on stand-by.
3. Water Feeding Pumps	2	Each 200 gpm, metering pumps
4. Piping	1,000 lf	6 in. dia. (insulated).
5. Secondary Mixing Tank	2	Two 60,000 gallon steel tanks with mixers.
6. Separator	1	Same as above.
7. Sludge Pumps	2	Each 150 gpm, diaphragm pumps
IV. EXTRACTANT TREATMENT SYSTEM		
1. Extractant Oxidation		
o Reactor Tanks	2	Two 30 ft dia 12 ft sidewall reactor tanks, open top epoxy lined steel tank, 4 baffles - 90° apart, 12 ft deep, 1 ft wide, top to contain agitation mounting.
o Agitators	2	Two agitators, 2 - four pitch blade turbine impellers, top mounted, shaft 12 ft, stainless steel.
o Acid Feeders	2	Metering pumps, 40 gph, stainless steel.
o Acid Storage Tank	1	3,000 gal carbon steel, horizontal tank, rubber lined.
o Potassium Permanganate Silo	1	2,000 gal steel tank, elevated steel structure support.
o Potassium Permanganate Feeder	2	Each 1.0 lb/min adjustable, loss in weight type dry feeders.

TABLE A-4 (Cont'd)

ALTERNATIVE 3A - DREDGING/EXTRACTION/SEDIMENTS TO OFF-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
2. Extractant Coagulation/Flocculation/ Precipitation		
o Coagulator - Clarifiers	2	Each 48 ft dia coagulator/clarifier, 12 ft sidewall depth, bottom slope 3 in/ft, concrete bottom, steel tank epoxy lined, heavy duty rake mechanism.
o Sludge Pumps	4	Four 10 gpm, diaphragm pumps.
o Water Pumps	4	200 gpm, TDH = 25 ft, HP = 4.2
o Ferric Chloride Storage Tank	1	12 ft dia, 15 ft vertical, cone roof, steel bottom, carbon steel tank, rubber lined.
o Ferric Chloride Feeders	2	30 gph metering pumps, Teflon lined.
o Polymer Feeders	2	20 gph metering pump each, stainless steel 316.
o Polymer Day Tank	1	200 gal day tank, fiberglass reinforced polyester.
o Caustic Storage Tank	1	1,000 gal steel tank, rubber lined.
o Caustic Feeders	2	40 gph, metering pumps stainless steel 316.
V. OFF-SITE NON-HAZARDOUS DISPOSAL	105,360 ton	Trucked to non-hazardous landfill sites (within 100 miles from Union Lake), 150 ton/day.
VI. OFF-SITE HAZARDOUS DISPOSAL	8,540 ton	Trucked to RCRA "C" landfill sites
VII. PROCESS PIPING AND I&C		For the above treatment facilities.
VIII. PROCESS CHEMICALS AND MATERIALS		
1. Coagulant (Alum)	405 ton	
2. Polymer	101 ton	
3. Ferric Chloride	3,520 ton	

TABLE A-4 (Cont'd)

ALTERNATIVE 3A - DREDGING/EXTRACTION/SEDIMENTS TO OFF-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
4. Hydrochloric Acid	810 ton	
5. Potassium Permanganate	405 ton	
6. Sodium Hydroxide	5,420 lb	
IX. ELECTRICAL AND POWER		For the above treatment facilities
X. MANPOWER		
1. Manager	1	Two years operation after one year construction
2. Supervisor	3	Two years operation after one year construction
3. Operator	12	Two years operation after one year construction
4. Labor	6	Two years operation after one year construction
XI. BUILDINGS, PLATFORMS & STAIRS		For the above treatment facilities
XII. FOUNDATIONS & PADS		For the above treatment facilities

TABLE A-5

ALTERNATIVE 3B - DREDGING/THICKENING/EXTRACTION/SEDIMENTS TO ON-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SEDIMENT HYDRAULIC DREDGING	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT CHEMICAL EXTRACTION SYSTEM	Same as Alt. 3A, Item III	Same as Alt. 3A, Item III
IV. EXTRACTANT TREATMENT SYSTEM	Same as Alt. 3A, Item IV	Same as Alt. 3A, Item IV
V. ON-SITE NON-HAZARDOUS LANDFILL		
1. Liner System		
o Clay Layer	15,250 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Synthetic Liner	202,700 sf	60 mil high density polyethylene (HDPE)
o Leachate Collection System		
- PVC Pipe	2,050 ft	6 in. dia perforated
- RC Sump	2	4 ft dia, 5 ft deep
- Pumps	2	25 gpm each, chemical resistant
o Sand Layer	10,400 cy	2 ft thick sand layer
2. Processed Sediment Deposition and Compaction	70,200 cy	100 cy/day
3. Capping System		
o Clay Layer	14,600 cy	2 ft thick clay (permeability 10^{-7} cm/sec)
o Drain Layer	10,400 cy	1 ft thick sand layer
o Top Soil	15,150 cy	6 in. topsoil
o Vegetation	5 acres	

TABLE A-5 (Cont'd)

ALTERNATIVE 3B - DREDGING/EXTRACTION/SEDIMENTS TO ON-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
V. ON-SITE NON-HAZARDOUS LANDFILL (Cont'd)		
4. Drainage Ditch	2,210 ft	Top Width - 20 ft, Total Depth = 2 ft Bottom Width - 2 ft, Side Slope - 2:1
o Clay Layer	6,360 cy	2 ft thick clay (permeability - 10^{-7} cm/sec)
o Topsoil	2,120 cy	2 ft thick topsoil
o Vegetation	.55 acres	
VI. OFF-SITE HAZARDOUS DISPOSAL	Same as Alt. 3A, Item VI	Same as Alt. 3A, Item VI
VII. PROCESS PIPING AND I&C	Same as Alt. 3A, Item VII	Same as Alt. 3A, Item VII
VIII. PROCESS CHEMICALS AND MATERIALS	Same as Alt. 3A, Item VIII	Same as Alt. 3A, Item VIII
IX. ELECTRICAL AND POWER	Same as Alt. 3A, Item IX	Same as Alt. 3A, Item IX
X. MANPOWER	Same as Alt. 3A, Item X	Same as Alt. 3A, Item X

TABLE A-6

ALTERNATIVE 3C - DREDGING/EXTRACTION/DEEP LAKE DEPOSITION FOR SEDIMENTS/OFF-SITE
HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION CONPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. SEDIMENT HYDRAULIC DREDGING	Same as Alt. 2A, Item II	Same as Alt. 2A, Item II
III. SEDIMENT EXTRACTION SYSTEM	Same as Alt. 3A, Item III	Same as Alt. 3A, Item III
IV. EXTRACTANT TREATMENT SYSTEM	Same as Alt. 3A, Item IV	Same as Alt. 3A, Item IV
V. DEEP LAKE DEPOSITION	70,200 cy	Treated sediments to be barged to central, deep areas of Union Lake and deposited of at a rate of 110 cy day
VI. OFF-SITE HAZARDOUS DISPOSAL	Same as Alt. 3A, Item VI	Same as Alt. 3A, Item VI
VII. PROCESS PIPING I&C	Same as Atl. 3A, Item VII	Same as Atl. 3A, Item VII
VIII. PROCESS CHEMICALS AND MATERIALS	Same as Alt. 3A, Item VIII	Same as Alt. 3A, Item VIII
IX. ELECTRICAL AND POWER	Same as Alt. 3A, Item IX	Same as Alt. 3A, Item IX
X. MANPOWER	Same as Alt. 3A, Item X	Same as Alt. 3A, Item X

TABLE A-7

ALTERNATIVE 5 - IN-SITU SAND COVERING
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alt. 2A, Item I	Same as Alt. 2A, Item I
II. COARSE SAND COVER INSTALLATION	130,000 cy	Coarse sand to be trucked to site. Barges and bulldozers to deposit 1 ft layer of sand over contaminated sediments.

9337b

APPENDIX B

DETAILED BREAKDOWN OF CAPITAL AND

OPERATION AND MAINTENANCE

COST ESTIMATES

9337b

TABLE B-1

ALTERNATIVE 1 – NO-ACTION
CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
I. POSTING OF WARNING SIGNS	75	100	7,500	100	7,500	$15,000
II. PUBLIC AWARENESS PROGRAM	2					$20,000
			Total Direct Construction Cost (TDCC)			$35,000
			Contingency @ 20% of TDCC			$ 7,000
			Engineering @ 5% of TDCC			$ 1,750
			Legal & Administrative @ 2% of TDCC			$ 700
				Total Construction Cost		$44,450

TABLE B-2

ALTERNATIVE 2A – DREDGING/THICKENING/FIXATION/OFF-SITE NON-HAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION						
1. Support Facilities	5	15,600	78,000			$ 78,000
2. Security Fence & Gate	1,000 lf	17.60	17,600	33.15	33,150	$ 50,750
3. Parking Area	1,110 sf	7.50	8,325	6.78	7,525	$ 15,850
4. Access Road	2,780 sf	11.70	32,530	14.94	41,530	$ 74,060
				Subtotal		$ 218,660
II. SEDIMENT HYDRAULIC DREDGING	351,000 cy			5.76	2,104,760	$2,021,760
III. SEDIMENT GRAVITY THICKENING SYSTEM						
1. Gravity Thickener	2	95,000	190,000	36,950	73,900	$ 263,900,
2. Sediment Pumps	2	8,550	17,100	3,250	6,500	$ 23,600
				Subtotal		$ 287,500
IV. SUPERNATANT TREATMENT SYSTEM						
1. Coagulator – Clarifiers	2	92,740	185,480	24,300	48,600	$ 234,080
2. Sludge Pumps	2	3,200	6,400	890	1,780	$ 8,180
3. Coagulant Feeding Pumps	2	1,900	3,800	510	1,020	$ 4,820
4. Coagulant Day Tank	1	6,000	6,000	2,295	2,295	$ 8,295
5. Polymer Feeding Pumps	2	1,200	2,400	510	1,020	$ 3,420

TABLE B-2 (Cont'd)

ALTERNATIVE 2A - DREDGING/THICKENING/FIXATION/OFF-SITE NON-HAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
IV. SUPERNATANT TREATMENT SYSTEM (Cont'd)						
6. Polymer Day Tank	1	4,400	4,400	2,040	2,040	$ 6,440
7. Ferric Chloride Feeding Pumps	2	1,900	3,800	765	1,530	$ 5,330
8. Ferric Chloride Day Tank	1	6,000	6,000	2,295	2,295	$ 8,295
					Subtotal	$ 278,860
V. CHEMICAL FIXATION SYSTEM						
1. Slurry Mixing Tank	2	10,970	21,940	4,210	8,420	$ 30,360
2. Mixers	2			Included in Mixing Tank		
3. Chemical Tank (K-20 LSC)	1	10,000	10,000	3,825	3,825	$ 13,825
4. Chemical Feeding Pumps	2	1,900	3,800	765	1,530	$ 5,330
5. Carbon Powder Silo	1	4,500	4,500	1,785	1,785	$ 6,285
6. Carbon Powder Feeding Systems	2	21,000	42,000	1,275	2,550	$ 44,550
7. Portland Cement Silo	1	33,000	33,000	51,000	51,000	$ 84,000
8. Portland Cement Feeding Systems	2	17,500	35,000	1,275	2,550	$ 37,550
9. Fly Ash Silo	1	16,000	16,000	25,500	25,500	$ 41,500
10. Fly Ash Feeding Systems	2	15,000	30,000	1,275	2,550	$ 32,550
					Subtotal	$ 295,970
VI. FIXATED SEDIMENT CURING SYSTEM						
1. Curing Basin Dike	600 ft	2.45	1,470	17.85	10,710	$ 12,180

TABLE B-2 (Cont'd)

ALTERNATIVE 2A – DREDGING/THICKENING/FIXATION/OFF-SITE NON-HAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
VI. FIXATED SEDIMENT CURING SYSTEM (Cont'd)						
2. Clay Layer	850 cy	20	17,000	10.00	8,500	$ 25,500
					Subtotal	$ 37,680
VII. OFF-SITE NON-HAZARDOUS DISPOSAL	209,120 ton			100	20,912,000	$ 20,912,000
VIII. PROCESS PIPING AND I&C	LS		38,000		63,750	$ 101,750
IX. PROCESS CHEMICALS AND MATERIALS						
1. Coagulant (Alum.)	80 ton	246	19,680			$ 19,680
2. Polymer	22 ton	4,000	88,000			$ 88,000
3. Ferric Chloride	80 ton	860	68,800			$ 68,800
4. K-20 LSC	638,700 gal	40	15,967,500			$ 15,967,500
5. Activated Carbon	8,520 ton	1,600	13,632,000			$ 13,632,000
6. Portland Cement	76,640 ton	70	5,364,800			$ 5,364,200
7. Fly Ash	25,550 ton	50	1,277,500			$ 1,277,500
					Subtotal	$ 36,417,480
X. ELECTRICAL						
1. Installation	LS		200,000		173,400	$ 373,400
2. Power Cost						$ 68,000
					Subtotal	$ 441,400
XI. MANPOWER						
1. Manager	1					$ 120,000
2. Supervisors	2					$ 180,000
3. Operators	4					$ 280,000
4. Laborers	4					$ 240,000
					Subtotal	$ 820,000

TABLE B-2 (Cont'd)

ALTERNATIVE 2A - DREDGING/THICKENING/FIXATION/OFF-SITE NON-HAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
XII. BUILDING, PLATFORMS & STAIRS	LS		244,000		71,400	$ 315,400
XIII. FOUNDATIONS & PADS	LS		40,000		61,200	$ 101,200

Total Direct Construction Cost (TDCC)	$	62,249,660
Contingency @ 20% of TDCC	$	12,449,932
Engineering @ 5% of TDCC	$	3,112,483
Legal and Administrative @ 2% of TDCC	$	1,249,932
Total Construction Cost	$	79,062,007

9337b

TABLE B-3

ALTERNATIVE 2B - DREDGING/THICKENING/FIXATION/ON-SITE NON-HAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION (See Table B-2)						$ 218,660
II. SEDIMENT HYDRAULIC DREDGING (See Table B-2)						$ 2,021,760
III. SEDIMENT GRAVITY THICKENING SYSTEM (See Table B-2)						$ 287,500
IV. SUPERNATANT TREATMENT SYSTEM (See Table B-2)						$ 278,860
V. CHEMICAL FIXATION SYSTEM (See Table B-2)						$ 295,970
VI. FIXATED SEDIMENT CURING SYSTEM (See Table B-2)						$ 37,680
VII. ON-SITE NON-HAZARDOUS LANDFILL						
1. Liner System						
o Clay Layer	24,600 cy	20	492,000	10	246,000	$ 738,000
o Synthetic Liner	329,000 sf	0.90	296,100	0.26	30,890	$ 326,990
o Leachate Collection System						
- PVC Pipe	3,300 ft	0.85	2,800	4.59	15,150	$ 17,950
- RC Sumps	2	600	1,200	1,020	2,040	$ 3,240
- Pumps	2	5,500	11,000	1,530	3,060	$ 14,060
o Sand Layer	20,100 cy	12.75	256,280	2.30	46,230	$ 302,510
2. Fixated Sediment Deposition and Compaction	116,000 cy			5.25	609,000	$ 609,000
3. Capping System						
o Clay Layer	31,850 cy	20	637,000	22.95	730,960	$1,367,960
o Drainage Layer	17,200 cy	12.75	155,060	2.30	28,060	$ 183,120

TABLE B-3 (Cont'd)

ALTERNATIVE 2B – DREDGING/THICKENING/FIXATION/ON-SITE NON-HAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
o Topsoil	24,800 cy	16.10	399,280	4.54	112,590	$ 511,870
o Vegetation (Grass Seeding)	5 acres	1,100	5,500	668	3,340	$ 8,840
4. Drainage Ditch	1,960 ft	–	–	4.59	9,000	$ 9,000
o Clay Layer	9,600 cy	20.00	192,000	12	115,200	$ 307,200
o Topsoil	3,200 cy	16.10	51,520	6.63	21,228	$ 72,740
o Vegetation (Grass Seeding)	.83 acres	1,100	990	668	600	$ 1,460
					Subtotal	$ 4,183,180
VIII. PROCESS PIPING AND I&C						$ 101,750
(See Table B-2)						
IX. PROCESS CHEMICALS AND MATERIALS						$36,417,480
(See Table B-2)						
X. ELECTRICAL & POWER						
(See Table B-2)						$ 441,400
XI. MANPOWER						$ 820,000
(See Table B-2)						
XII. BUILDING, PLATFORM & STAIRS						$ 315,400
(See Table B-2)						
XIII. FOUNDATIONS & PADS						
(See Table B-2)						$ 101,200
	Total Direct Construction Cost (TDCC)					$45,520,840
	Contingency @ 20% of TDCC					$ 9,104,168
	Engineering @ 5% of TDCC					$ 2,276,042
	Legal and Administrative @ 2% of TDCC					$ 910,417
				Total Construction Cost		$57,811,467

TABLE B-4

ALTERNATIVE 3A - DREDGING/EXTRACTION/SEDIMENTS TO OFF-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION						
(See Table B-2)						$ 218,660
II. SEDIMENT HYDRAULIC DREDGING						$2,021,760
(See Table B-2)						
III. SEDIMENT EXTRACTION SYSTEM						
1. Mixing Tanks	2	70,000	140,000	125,000	60,000	$ 200,000
2. Separator	1	38,500	38,500	5,780	5,780	$ 44,280
3. Water Feeding Pumps	2	4,700	9,400	1,300	2,600	$ 12,000
4. Piping	1,000 lf	70	20,000	60	60,000	$ 80,000
5. Secondary Mixing Tanks	2	70,000	140,000	30,000	60,000	$ 200,000
6. Separator	1	38,500	38,500	5,780	5,780	$ 44,280
7. Sludge Pumps	2	6,700	13,400	2,550	5,100	$ 18,500
					Subtotal	$ 599,060
IV. EXTRACTANT TREATMENT SYSTEM						
1. Extractant Oxidation						
o Reactor Tanks	2	29,900	59,800	38,130	76,200	$ 136,060
o Agitators	2	11,000	22,000	1,530	3,060	$ 25,060
o Acid Feederss	2	2,500	5,000	510	1,020	$ 6,020
o Acid Storage Tank	1	6,000	6,000	1,530	1,530	$ 7,530
o Potassium Permanganate Silo	1	5,000	5,000	1,785	1,785	$ 6,785
o Potassium Permanganate Feeders	2	30,000	60,000	1,275	2,550	$ 62,550

TABLE B-4 (Cont'd)

ALTERNATIVE 3A - DREDGING/EXTRACTION/SEDIMENTS TO OFF-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
2. Extractant Coagulation/Flocculation/ Precipitation						
o Coagulator - Clarifiers	2	491,750	983,500	179,140	358,300	$ 1,341,800
o Sludge Pumps	2	5,500	11,000	2,040	4,080	$ 15,080
o Water Pumps	4	4,700	18,800	1,300	5,200	$ 24,000
o Ferric Chloride Storage Tank	1	9,500	9,500	7,650	7,650	$ 17,150
o Ferric Chloride Feeders	2	2,900	5,800	510	1,020	$ 6,820
o Polymer Feeders	2	10,000	20,000	2,000	4,000	$ 24,000
o Polymer Day Tank	1	4,400	4,400	2,040	2,040	$ 6,440
o Caustic Storage Tank	1	15,000	15,000	4,000	4,000	$ 19,000
o Caustic Feeders	2	2,500	5,000	510	1,020	$ 6,020
					Subtotal	$ 1,704,315
V. OFF-SITE NON-HAZARDOUS DISPOSAL	105,360 ton			100	10,536,000	$10,536,000
VI. OFF-SITE HAZARDOUS DISPOSAL	8,540 ton			230	1,964,200	$ 1,964,200
VII. PROCESS PIPING AND I&C	LS		120,000		200,000	$ 320,000
VIII. PROCESS CHEMICALS AND MATERIALS						
1. Coagulant (Alum)	226 ton	246				$ 55,600
2. Polymer	57 ton	4,000				$ 228,000
3. Ferric Chloride	1,966 ton	860				$ 1,690,760
4. Hydrochloric Acid	453 ton	100				$ 45,300
5. Potassium Permanganate	226 ton	2,400				$ 542,400
6. Sodium Hydroxide	3,027 lb	0.74				$ 2,240
					Subtotal	$ 2,564,300

9337b

TABLE B-4 (Cont'd)

ALTERNATIVE 3A - DREDGING/EXTRACTION/SEDIMENTS TO OFF-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
IX. ELECTRICAL AND POWER						
1. Installation			210,000		175,400	$ 435,400
2. Power Cost						$ 95,000
					Subtotal	$ 530,400
X. MANPOWER						
1. Manager	1					$ 150,000
2. Supervisor	3					$ 405,000
3. Operator	12					$ 1,260,000
4. Labor	6					$ 450,000
					Subtotal	$ 2,355,000
XI. BUILDING, PLATFORMS & STAIRS	LS		330,000		8,000	$ 410,000
XII. FOUNDATIONS & PADS	LS		67,000		200,000	$ 267,000
		Total Direct Construction Cost (TDCC)				$23,490,295
		Contingency @ 20% of TDCC				$ 4,698,060
		Engineering @ 5% of TDCC				$ 1,174,515
		Legal and Administrative @ 2% of TDCC				$ 469,810
				Total Construction Cost		$29,832,680

TABLE B-5

ALTERNATIVE 3B - DREDGING/EXTRACTION/SEDIMENTS TO ON-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
I. SITE PREPARATION						
(See Table B-2)						$ 218,660
II. SEDIMENT HYDRAULIC DREDGING						$2,021,760
(See Table B-2)						
III. SEDIMENT EXTRACTION SYSTEM						$ 599,060
(See Table B-5)						
IV. EXTRACTANT TREATMENT SYSTEM						$1,704,315
(See Table B-5)						
V. ON-SITE NON-HAZARDOUS LANDFILL						
1. Liner System						
o Clay Layer	15,250 cy	20	305,000	10.00	152,500	$ 457,500
o Synthetic Liner	457,000 sf	0.90	202,700	0.26	182,430	$ 235,130
o Leachate Collection System						
- PVC Pipe	2,050 ft	0.85	1,740	4.59	9,410	$ 11,150
- RC Sumps	2	600	1,200	1,020	2,040	$ 3,240
- Pumps	2	5,500	11,000	1,530	3,060	$ 14,060
o Sand Layer	10,400 cy	12.75	132,600	2.30	23,920	$ 156,520
2. Fixated Sediment Deposition and Compaction	70,200 cy			5.25	368,550	$ 368,500
3. Capping System						
o Clay Layer	14,600 cy	20	292,000	22.95	335,070	$ 627,070
o Drain Layer	10,400 cy	12.75	132,600	2.30	23,920	$ 156,520
o Top Soil	15,150 cy	16.10	243,920	4.54	68,780	$ 312,200
o Vegetation (Grass Seeding)	5 acres	1,100	5,500	668	3,340	$ 8,840

TABLE B-5 (Cont'd)

ALTERNATIVE 3B - DREDGING/EXTRACTION/SEDIMENTS TO ON-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
4. Drainage Ditch	2,210 ft			4.59	10,140	$ 10,140
o Clay Layer	6,360 cy	20	127,200	12	76,320	$ 203,520
o Topsoil	2,120 cy	26.10	55,330	6.63	14,060	$ 64,390
o Vegetation (Grass Seeding)	.55 acres	1,100	605	668	370	$ 975
					Subtotal	$ 2,635,305
VI. OFF-SITE HAZARDOUS DISPOSAL						$ 1,964,200
(See Table B-5)						
VII. PROCESS PIPING AND I&C						$ 320,000
(See Table B-5)						
VIII. PROCESS CHEMICALS AND MATERIALS						$ 2,564,300
(See Table B-5)						
IX. ELECTRICAL & POWER						$ 530,400
(See Table B-5)						
X. MANPOWER						$ 2,355,000
(See Table B-5)						
XI. BUILDING, PLATFORMS & STAIRS						$ 410,000
(See Table B-5)						
XII. FOUNDATION & PADS						$ 267,000
(See Table B-5)						

Total Direct Construction Cost (TDCC)	$15,589,340
Contingency @ 25% of TDCC	$ 3,117,870
Engineering @ 5% of TDCC	$ 779,470
Legal and Administrative @ 2% of TDCC	$ 311,790
Total Construction Cost	$19,798,470

9337b

TABLE B-6

ALTERNATIVE 3C - DREDGING/EXTRACTION/DEEP LAKE DEPOSITION FOR SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION (See Table B-2)						$ 218,660
II. SEDIMENT HYDRAULIC DREDGING (See Table B-2)						$ 2,021,760
III. SEDIMENT EXTRACTION SYSTEM (See Table B-5)						$ 599,060
IV. EXTRACTANT TREATMENT SYSTEM (See Table B-5)						$ 1,704,315
V. DEEP LAKE DEPOSITION	70,200 cy			5.00	351,000	$ 351,000
VI. OFF-SITE HAZARDOUS DISPOSAL (See Table B-5)						$ 1,964,200
VII. PROCESS PIPING AND I&C (See Table B-5)						$ 320,000
VIII. PROCESS CHEMICALS AND MATERIALS (See Table B-5)						$ 2,564,300
IX. ELECTRICAL & POWER (See Table B-5)						$ 530,400
X. MANPOWER (See Table B-5)						$ 2,355,000
XI. BUILDING, PLATFORMS & STAIRS (See Table B-5)						$ 410,000

TABLE B-6 (Cont'd)

ALTERNATIVE 3C - DREDGING/EXTRACTION/DEEP LAKE DEPOSITION FOR SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST
XII. FOUNDATION & PADS						$ 267,000
(See Table B-5)						
		Total Direct Construction Cost (TDCC)				$ 13,305,695
		Contingency @ 25% of TDCC				$ 2,661,140
		Engineering @ 5% of TDCC				$ 665,285
		Legal and Administrative @ 2% of TDCC				$ 266,120
				Total Construction Cost		$ 16,898,240

TABLE B-7

ALTERNATIVE 5 - IN-SITU SAND COVERING

CAPITAL COST ESTIMATES (1989 DOLLARS)

FACILITY/ CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION						$ 218,660
(See Table B-2)						
II. COARSE SAND COVER INSTALLATION	130,000 cy	12.75	1,657,500	4.0	520,000	$ 2,177,500
			Total Direct Construction Cost (TDCC)			$ 2,396,160
			Contingency @ 20% of TDCC			$ 479,230
			Engineering @ 5% of TDCC			$ 119,810
			Legal and Administrative @ 2% of TDCC			$ 47,920
			Total Construction Cost			$ 3,043,120

TABLE B-8

ALTERNATIVE 1 - NO ACTION

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE	O/M COST ESTIMATE	YEAR
1. Site Monitoring			
a. Visit Inspection & Report	1 person @ $60/hr & 40 hrs/yr	$ 2,400	1-30
b. Ecological Survey and Sampling	6 person @ $60/hr 40 hrs/yr	$14,400	1-30
c. Laboratory Analysis	16 sediment samples @ $400/ sample	$ 6,400	1-30
	16 water samples @ $300/sample	$ 4,800	
	40 ecological samples @ $200/ sample	$ 8,000	
d. Report	2 person $ $60/hr, 40 hrs/yr	$ 4,800	1-30
	Subtotal	$40,800	1-30
2. Public Information Seminar	2 person @ $60/hr & 40 hrs/yr	$ 4,800	1-30
3. Maintenance			
Warning Signs	10% of capital cost	$ 1,500	1-30
4. Contingency	5% of O&M cost	$ 2,355	
	TOTAL ANNUAL O&M COST	$47,200	1-30

TABLE B-9

ALTERNATIVE 2A - DREDGING/THICKENING/FIXATION/
OFF-SITE NON-HAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989)

COST COMPONENT	BASIS OF ESTIMATE	O/M COST ESTIMATE	YEAR
1. Site Monitoring			
a. Visit Inspection and Report	1 person @ $60/hr	$ 2,400	4-33
b. Laboratory Analysis	16 sediment samples @ $400/sample	$ 6,400	4-33
	4 water samples @ $300/sample	1,200	
c. Report	1 person $60/hr, 40 hrs/yr	$ 2,400	4-33
	SUBTOTAL	$12,400	
2. Contingency	5 % of O&M Cost	$ 620	
	TOTAL ANNUAL O&M COST	$13,020	

TABLE B-10

ALTERNATIVE 2B - DREDGING/THICKENING/FIXATION/ON-SITE NON-HAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST

ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE		O/M COST ESTIMATE	YEAR
1. Landfill Monitoring				
a. Monitoring Landfill	2 persons @ $30/yr 8 hrs each, 2 yrs		$ 960	4-33
b. Laboratory Analysis	4 leachate samples 2 yrs @ $1000/sample		$ 8,000	4-33
c. Reports	1 engineer @ $60/hr, 8 hrs, 2 yrs.		$ 960	4-33
		Subtotal	$ 9,920	4-33
2. Landfill Maintenance				
a. Liner System	2% of Capital Cost		$28,000	4-33
b. Cap and Site Repair	2% of Capital Cost		$41,400	4-33
c. Drainage Ditch Repair	2% of Capital Cost		$ 7,980	4-33
d. Leachate Disposal	Assume 1000 gal/yr @ $1.00/gal		$ 1,000	4-33
		Subtotal	$78,380	4-33
3. Contingency	5% of O&M Cost		$ 4,420	
	TOTAL ANNUAL O&M COST		$92,730	4-33

TABLE B-11

ALTERNATIVE 3A - DREDGING/EXTRACTION/SEDIMENTS TO OFF-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989)

COST COMPONENT	BASIS OF ESTIMATE	O/M COST ESTIMATE	YEAR
1. Site Monitoring			
a. Visit Inspection and Report	1 person @ $60/hr	$ 2,400	4-33
b. Laboratory Analysis	16 sediment samples @ $400/sample	$ 6,400	4-33
	4 water samples @ $300/sample	1,200	
c. Report	1 person $60/hr, 40 hrs/yr	$ 2,400	4-33
	SUBTOTAL	$12,400	
2. Contingency	5 % of O&M Cost	$ 620	
	TOTAL ANNUAL O&M COST	$13,020	

TABLE B-12

ALTERNATIVE 3B - DREDGING/EXTRACTION/SEDIMENTS TO ON-SITE NON-HAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST

ESTIMATES (1989 DOLLARS)

COST COMPONENT	BASIS OF ESTIMATE		O/M COST ESTIMATE	YEAR
1. Landfill Monitoring	See Table B-9		$9,920	4-33
2. Landfill Maintenance				
a. Liner System	2% of Capital Cost		$17,550	4-33
b. Cap and Site Repair	2% of Capital Cost		$22,100	4-33
c. Drainage Ditch Repair	2% of Capital Cost		$ 5,680	4-33
d. Leachate Disposal	Assume 1000 gal/yr @ $1.00/gal		$ 1 000	4-33
		Subtotal	$46,330	
3. Contingency	5% of O&M Cost		$ 2,810	
	TOTAL ANNUAL O&M COST		$59,060	4-33

TABLE B-13

ALTERNATIVE 3C - DREDGING/EXTRACTION/DEEP LAKE DEPOSITION OF SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989)

COST COMPONENT	BASIS OF ESTIMATE	O/M COST ESTIMATE	YEAR
1. Site Monitoring			
a. Visit Inspection and Report	1 person @ $60/hr	$ 2,400	4-33
b. Laboratory Analysis	16 sediment samples @ $400/sample	$ 6,400	4-33
	4 water samples @ $300/sample	1,200	
c. Report	1 person $60/hr, 40 hrs/yr	$ 2,400	4-33
	SUBTOTAL	$12,400	
2. Contingency	5 % of O&M Cost	$ 620	
	TOTAL ANNUAL O&M COST	$13,020	

TABLE B-14

ALTERNATIVE 5 - IN SITU SAND COVER

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989)

COST COMPONENT	BASIS OF ESTIMATE	O/M COST ESTIMATE	YEAR
1. Site Monitoring			
a. Visit Inspection and Report	1 person @ $60/hr	$ 2,400	4-33
b. Laboratory Analysis	16 sediment samples @ $400/sample	$ 6,400	4-33
	4 water samples @ $300/sample	1,200	
c. Report	1 person $60/hr, 40 hrs/yr	$ 2,400	4-33
	SUBTOTAL	$12,400	
2. Contingency	5 % of O&M Cost	$ 620	
	TOTAL ANNUAL O&M COST	$13,020	

9337b

APPENDIX C

GEOSTATISTICAL ANALYSES OF SOIL ARSENIC DATA

9490b

GEOSTATISTICAL ANALYSES OF SOIL ARSENIC DATA

PURPOSE

Geostatistical analyses were performed on the soil arsenic data from the Union Lake Site. The purpose of the analysis was to prepare an unbiased estimate of the quantity of sediment which contained an arsenic concentration above the chosen action level of 20 mg/kg. This unbiased estimate could then be used as the basis for determining areas and depths of contamination.

METHODOLOGY

As discussed in the Draft Union Lake RI report (Ebasco, 1988), sediment sampling was performed during the investigation. Surface sediment samples and samples from 0-1 feet were taken at 62 locations.

All of the above samples were analyzed for total arsenic. The arsenic results are presented in Chapter 1 of this FS Report, and are discussed in detail in the Draft Union Lake Site RI. These samples provided the data base used to estimate the contaminated soil volumes.

The first step in the process was to determine the horizontal coordinates of each sediment sampling point. This was done for all surface samples and samples 0-1 ft. All the sample points were considered as being surface samples (i.e., depth not considered) and analyzed by the methods outlined in the Statistical Analyses section below to contour the arsenic data. Those areas within each depth range that displayed arsenic concentrations greater than 120 mg/kg were determined from the contours and were overlaid on a map of the lake showing the depth of water. This permitted determination of the areas that had arsenic concentrations greater than 120 mg/kg and a water depth up to 2.5 ft.

GEOSTATISTICAL ANALYSES

Although the algorithm used for the geostatistical analyses is unbiased the algorithm does contain numerous parameters. Therefore the first step in data reduction was to perform a detailed sensitivity analyses to determine what parameters had a significant affect on the contour maps generated. The magnitude of each effect was also determined. This data was then used to guide the second stage of data reduction and interpretation.

Results of the sensitivity analysis indicated that the contour maps produced were not significantly affected by variations of the contouring algorithm utilized. Minor differences in specific contours were observed, however, when calculations were made to estimate quantities of contaminated material. These differences were found to be insignificant when compared to the total quantity of material to be excavated.

Although variations in contouring algorithms were not identified as potential source of error, a secondary problem associated with any mathematical model needed to be considered. This problem, inherent in all mathematical interpolation algorithms, is known as the boundary affect. Empirically, for the Union Lake sediments, this resulted in contours within approximately 50-100 ft of a boundary being suspect. These contours needed to be evaluated by hand, based on professional judgement. This interpretation was performed in the second stage of data reduction.

Although the computer algorithm proved to be relatively insensitive to variations in input parameters a discussion of the various parameters evaluated is warranted. Input parameters, for this discussion, can be grouped into two categories:

1. parameters affecting data point selection, and

2. parameters affecting interpolation technique.

Parameters in the first category include the method of selecting data points for interpolation, the maximum distance between points to be evaluated, and how to handle duplicate data points. Parameters in the second category include which mathematical algorithm to use, distance weighing factor, and grid node spacing (roughly correlates to "how creative" one desires the computer to be).

Several factors had to be taken into account when defining a search methodology. Of primary concern is the spatial distribution of the data. Two different methods were applied in searching for data points to be evaluated in determining the value to be assigned to a grid location. The standard (NORMAL) method designed for randomly distributed data simply selects the (n) closest points. Values of (n) ranging from 3 to 10 were investigated.

The search radius is defined as the maximum distance at which a data point will be considered by the algorithm. In general the larger the search radius the smoother the resulting map. However, when there is a great amount of evenly distributed data the number of data points considered (n) is usually reached prior to the maximum search radius. A conservative search radius of 1000 ft was used because a geochemical influence at a node by a data point over 1000 ft away is technically unlikely.

The decision as to what type of interpolation algorithm was used for reducing the data depended on several factors, including data density and the physical process that was being investigated. A KRIGING algorithm was chosen as the method used to determine the weighted average of a data point when computing the value at a grid node. The KRIGING method was chosen instead of an INVERSE DISTANCE SQUARED (IDS) method. Although the data was fairly well distributed over the site this distribution was not totally uniform. If an IDS method of weighing had been used less realistic values would be calculated for grid nodes located in areas with low data density. In addition the assumption that arsenic concentration may be considered to vary over the lake in a continuous (although complex) manner is technically reasonable. This is one of the major assumptions that must be met in order for the KRIGING algorithm to be validly applied.

The weighted average, utilizing the KRIGING method, was related to the cube root of the distance between the data point and the grid node. Tests were conducted using this algorithm based on a square root and a fifth root distance weighing scheme, but because the data was distributed in a fairly uniform manner the weighing scheme was not as sensitive to variation as one might expect. Therefore a KRIGING algorithm based on the square root of the distance between points was used.

A grid size of 50 was chosen for the X axis which roughly corresponded to a grid line on each data point and one grid line interpolated between each data point. A higher density grid would provide more detailed contours, but they would be based to a much greater extent on computer interpolation of data. In addition, the increase in computer memory and processing time requirements is not a linear function and the resulting aesthetic improvement is not justified.

In addition to the above evaluating the above parameters individual contour lines were smoothed between grid nodes by a cubic spline method. This does not affect the values determined at each grid node (see discussion of KIRGING above). Therefore this smoothing does not override the KRIGING performed on the raw data.

ADJUSTMENT OF COMPUTER DATA

By applying the above contouring techniques on the soil arsenic data, maps were generated which showed contoured arsenic concentrations within each data set: surface and 0-1 foot depth. These maps were compared and overlaid to determine the unbiased estimate of the area and depth of soil containing an arsenic concentration above 120 mg/kg.

This process resulted in producing the sediment areas for remediation shown in Figure 3-1.